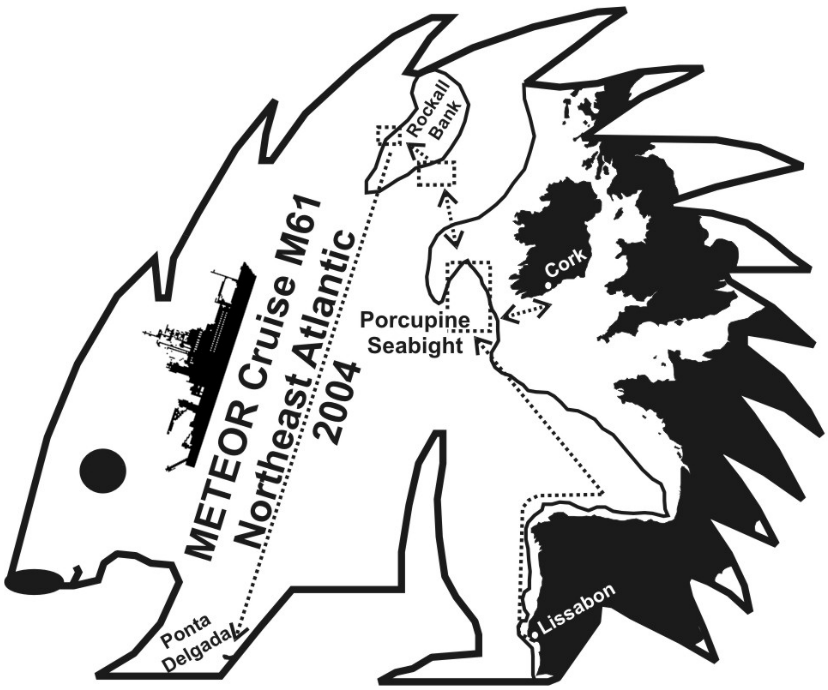
METEOR-Berichte 06-2

# Northeast Atlantic 2004

Cruise No. 61, Leg 1

April 19 to May 4, 2004, Lisbon – Cork




## Geo-Biological Investigations on Azooxanthellate Cold-Water Coral Reefs on the Carbonate Mounds Along the Celtic Continental Slope


Pfannkuche O., Bannert, B., Beck, T., Beuck, L., Dullo, W.-C., Flögel, S., Freiwald, A., Gass, S., Gektidis, M., Heger, A., Jamieson, A., Kavanagh, F., King, N., Kuhanec, B., Linke, P., Martin, B., Neulinger, S., Noe, S., Queisser, W., Rüggeberg, A., Ruseler, S., Schiemer, I., Schmidt, S., Schönfeld, J., Taviani, M., Türk, M., Vertino, A., Wigham, B.

**Table of Contents**

## 1.1 Participants

**Tab. 1.1** List of Participants on Leg M61-1 and Abbreviations

| | Name | Discipline | Institute |
|---|---|---|---|
| 1. | Pfannkuche, Olaf, Dr. | chief scientist, seafloor observation | IFM-GEOMAR |
| 2. | Bannert, Bernhard | video techniques | Oktopus |
| 3. | Beck, Tim | benthic ecology | IPAL |
| 4. | Beuck, Lydia | image analysis | IPAL |
| 5. | Dullo, Wolf-Christian, Prof. Dr. | paleo-oceanography | IFM-GEOMAR |
| 6. | Flögel, Sascha, Dr. | hydrography | IFM-GEOMAR |
| 7. | Freiwald, Andre, Prof. Dr. | paleo-oceanography | IPAL |
| 8. | Gass, Susan | benthic ecology | SAMS |
| 9. | Gektidis, Marcos, Dr. | scientif. docum./publ. outreach | IPAL |
| 10. | Heger, Amy | sea floor observatories | OceanLab |
| 11. | Jamieson, Alan, Dr. | seafloor observatories | OceanLab |
| 12. | Kavanagh, Fiona | benthic taxonomy | NUIG |
| 13. | King, Nicola | sea floor observatories | OceanLab |
| 14. | Kuhanec, Bettina | scientif. docum./publ. outreach | IPAL |
| 15. | Linke, Peter, Dr. | seafloor observatories | IFM-GEOMAR |
| 16. | Martin, Bettina, Dr. | planktology | IHF |
| 17. | Neulinger, Sven | microbiology | IFM_GEOMAR |
| 18. | Noe, Sybille, Dr. | paleo-oceanography | IFM-GEOMAR |
| 19. | Queisser, Wolfgang | gear technology | IFM-GEOMAR |
| 20. | Rüggeberg, Andres Dr. | paleo-oceanography | IFM-GEOMAR |
| 21. | Ruseler, Silke | planktology | IHF |
| 22. | Schiemer, Isabell | student paleo-oceanography | IPAL |
| 23. | Schmidt, Steffi | paleo-oceanography | IFM-GEOMAR |
| 24. | Schönfeld, Joachim, Dr. | paleo-oceanography | IFM-GEOMAR |
| 25. | Taviani, Marco, Dr. | paleontology | Uni Bologna |
| 26. | Türk, Mathias | electronics | IFM-GEOMAR |
| 27. | Vertino, Agostina, Dr. | benthic taxonomy | IPAL |
| 28. | Wigham, Ben, Dr. | sea floor observatories | OceanLab |

**Participating Institutions**

| | |
|---|---|
| IFM-GEOMAR: | Leibniz-Institut für Meereswissenschaften, an der Univ. Kiel, Germany |
| IHF | Inst. für Hydrobiologie und Fischereiwissenschaft, Univ. Hamburg, Germany |
| IPAL | Institut für Paläontologie, Univ. Erlangen, Germany |
| OceanLab | Ocean Laboratory, Univ. of Aberdeen, Newburgh, UK |
| Oktopus | Oktopus GmbH, Hohenweststedt, Kiel, Germany |
| SAMS: | Scottish Association for Marine Sciences, Oban, UK |
| NUIG | National Univ. of Ireland Galway, Martin Ryan Institute, Galway, Irleland |
| Uni Bologna | Univ. Bologna |

## 1.2 Research Program

The following objectives were addressed during M61-1:

- Water mass distribution and characteristics in the carbonate mound province

Carbonate mounds occur in a dynamic slope environment impacted by a strong tidal-driven hydrodynamic regime. CTD measurements during cruise M61-1 determined the small scale spatial variability of water masses in the carbonate mound and deep water coral realm. A series of high-resolution CTD profiles across Galway Mound and Thérèse Mound (Belgica Mound Province - BMP) and across Kiel Mount (Rockall Bank) has been carried out. Water close to the seafloor, was sampled with the Rosette water sampler combined with the CTD to study stable isotope composition in the benthic boundary layer,

- Longterm benthic boundary layer (BBL) processes in a living coral environment.

A long-term observatory (GEOMAR Modular Lander) instrumented by IFM-GEOMAR and SAMS was deployed on Galway Mound until mid of August (recovery Poseidon Cruise 316) to monitor the near seabed current-, CTD-regime and particle dynamics in a living coral ecosystem and to take time lapse stereo-photos of benthic activity (IFM-GEOMAR). SAMS estimated near-bed particle dynamics by integrating optical instruments and a data logger into the GEOMAR lander

- Short term sea floor observations of BBL processes

The work of the OceanLab group focused around the use of the ISIT camera that has been mounted on another GEOMAR Modular Lander. The ISIT lander used a very sensitive ISIT camera (rated to 6000m) to record bioluminescence events. Another scientific objective was to deploy the bait carrying Oceanlab ROBIO lander to get some time-lapse still images of the nekton and megabenthos community associated with *Lophelia*.

- Zooplankton distribution at carbonate mounds

Planktological studies dealt with the question if deep-water corals, which are potential predators for zooplankton, may have a direct impact on the composition and abundance of zooplankton. The study focused on the vertical distribution of meso-zooplankton over the carbonate mounds and outside their influence. Two layers were of special interest: the deep scattering layer with its vertically migrating organisms, and the near-bottom layer, which is of great importance for exchange processes between the water column and the sea floor.

- Mapping of biological habitats and sedimentary facies

Selected mounds were mapped with OFOS (Ocean floor observation system) to detect patterns of biological zones and sedimentary features, megafauna distribution and human impact to the coral ecosystem through ongoing trawling activities. The already existing ROV (Remotely Operated Vehicle) documentations of previous cruises showed that each mound province exhibits specific habitat patterns so that unifying models explaining ecological functioning of corals and mound formation are not yet conclusive. The OFOS systems provided substantial new data to understand the site-specific patterns such as diverse colonization patterns predominantly by a comparison between thriving coral mounds vs. dying coral mounds using statistical image analysis of underwater video documentations. Sediment samples collected will contribute to the identification of species richness and their role within the ecosystem.

- Paleo-environmental reconstruction of carbonate mounds

So far, few data exist that help to understand the ancient history of carbonate mounds and their biota. Box- and gravity coring on selected mounds and off-mound areas was carried out to analyse the role of corals in mound formation and the general understanding of deposited sedimentary sequences and their accumulation rates during the glacial-interglacial transition. Recent discoveries of cemented carbonate strata or crusts answered why the often steep-inclined slopes of the mound do not collapse or become eroded with time. Despite the ambient cool water and great depths, precipitation of carbonate crusts or hard grounds is a common process even in the NE-Atlantic, but the questions of what drives carbonate diagenesis and when does it happen are still unresolved. So far, only few hard ground samples exist because of inadequate sampling gear. On M61-1 the operation of the hydraulic TV-grab provided the unique opportunity to collect carbonate hard grounds and crusts.

## 1.3 Narrative of the cruise

Sunday 18.4. 2004 - The vanguard of the scientific party boarded R/V METEOR at 9.00h and started with the unloading of three containers. The main scientific party arrived in the course of the afternoon. The rest of day was spent with the distribution of equipment to the laboratories and with technical installations of sampling gear.

Monday 19.4.2004 - R/V METEOR left Lisbon harbour at 10.30h with a group of 28 scientists. From the mouth of the Tejo River we took a northern course along the west coast of the Iberian Peninsula. We encountered a heavy swell of appr. 8 m from the North West. The day was spent with the preparation of the laboratories, the construction of sampling gear and a plenary scientific meeting. Weather conditions remained unchanged.

Tuesday 20.4.2004 - In the evening, we reached the Cap Finistere region and started our crossing of the Bay of Biscay. Gear preparations especially the rigging of the lander systems continued.

Wednesday 21.4.2004 - We continued our crossing of the Bay of Biscay. The swell changed the direction to west and caused an unpleasant rolling of the ship. Gear preparation continued.

Thursday 22.4.2004 - We arrived at our first station at 51° 10´N, 11° 40´W in the southern Belgica Mound province in the afternoon. Station work started with the deployment of the ROBIO Lander (Stat. 202). After the test drive of a few winches to test a new EPROM we left the locality and steamed 17nm to the north to survey two mounds west and southeast of Therese Mound with the OFOS system (Stat. 203-204). So far, both mounds had not been investigated. We named them Castor and Pollux Mounds. Both were covered by rich thickets of corals. We started the night with a highly resolved longitudinal CTD/Ro transect across Galway and Little Galway Mound (Stat205-214).

Friday 23.4.2004 - We finished the longitudinal CTD/Ro transect in the morning. Next was a series of Van Veen Grab casts (Stat. 215-218) in the vicinity of the Therese Mound including the Castor and Pollux Mounds. The early afternoon was spent with the deployment of the BCL-Lander on Galway Mound (Stat. 219). Afterwards R/V METEOR headed south to the ROBIO-deployment site (Stat. 220). The lander was successfully recovered and had worked well. We then steamed back to the area south of Galway Mound to sample sediments with a box grab (Stat.221-226).

Saturday 24.4.2004 - Box grab sampling ended in the morning and was followed by a highly resolved latitudinal CTD/Ro transect across Galway Mound (Stat. 227-233). The first MOCNESS net was towed across Galway Mound in the afternoon (Stat. 234). Unfortunately, one of the nets touched the bottom of the mound plateau but retrieved a rich collection from a coral thicket environment. In the late afternoon we retrieved the BC-Lander (Stat. 235). The rest of the day and part of the following night was again dedicated to two MOCNESS transects (Stat.236-237).

Sunday 25.4.2004 - Another series of 6 van Veen grabs was taken north and east of Galway Mound (Stat. 238-243) followed by another MOCNESS haul (Stat. 244). In the afternoon we deployed the DOS-lander (Stat. 245) instrumented with a wide range of equipment and experimental trays on the top plateau of Galway Mound. This lander was moored for 110 days and will be retrieved with R/V POSEIDON around 10.8.2004. Next came another deployment of the ROBIO Lander (Stat. 246) west of Galway Mound. The rest of the day was spent with two OFOS transects across an hitherto unexplored mound at 51°29N, 11° 42,30´W´ which was named Erik Mound and at an escarpment along the 660m contour further to the south (Stat. 247-248).

Monday 26.4.2004 - The night until mid morning was dedicated to another CTD/Ro survey (Stat. 249-256). Next we deployed the BC-Lander (Stat. 257) and retrieved the ROBIO lander (Stat. 258). A CTD in the afternoon had to be cancelled for technical reasons and was replaced by a van Veen grab reference sample at the DOS deployment site (Stat. 259). The TV-grab was employed on the escarpment surveyed the day before to retrieve exposed carbonates (Stat. 260). Although the gear fell over during sampling procedure we were able to sample sufficient material. Two MOCNESS transects were driven during the late evening and the first half of the night (Stat. 262-262).

Tuesday 27.4.2004 - The second half of the night and the early morning was spent with van Veen grab sampling (Stat. 263-266) followed by two MOCNESS hauls until early afternoon (Stat. 267-268). In the course of the afternoon and early evening we retrieved the BC-Lander (Stat. 269) and succeeded to retrieve two 2.70m and 4.05m long gravity cores on Pollux Mound (Stat. 270-271). The night was spent with a box grab sampling survey with 6 successful deployments (Stat. 272-277).

Wednesday 28.4.2004 - The early morning was spent with another CTD/Ro survey (278-280). We then switched over to gravity coring which gained a successful core of 5.12 m and one empty core (Stat. 281-282). After a successful multiple corer haul and a final CTD/Ro cast (Stat. 283) we finished our station work at the Belgica Mound Province in the afternoon and headed in north-west direction towards the second working area at the south-western flank of the vast Rockall Bank.

Thursday 29.4.2004 - We continued our steaming to the Rockall area. Strong head winds reduced our cruising speed significantly to about 7-8kn.

Friday 30.4.2004 - We arrived at our second working area at 56° 40´N, 17° 34´W in the morning. First target was a volcanic structure that pierced through the gently dipping margin of the Rockall Bank. After a mapping survey with HYDROSWEEP (Stat. 284) and the deployment of the BC-Lander and the ROBIO-lander (Stat. 285-286) we selected two transects for the OFOS across the newly chartered mount (Stat. 287-288). The rough summit of the volcanic structure, that we call now "**Kiel Mount**", was covered by mostly fossil coral thickets. We documented a number of lithified carbonate sediments or hardgrounds. Larger drop stones were colonised by huge sea fans or black corals. The mid-slope of Kiel Mount is patchily plastered with carbonate crusts that show prominent dissolution features and often are out washed beneath the crust. Sediment filled dissolution cracks were abundantly inhabited by sea pens.

Saturday 1.5.2004 - We spent the night with two highly resolved CTD/Ro transects across Kiel Mount (Stat. 289-297). The BC-Lander and the ROBIO-lander were retrieved in the morning

(Stat298-299). This was followed by TV-grab sampling of carbonate crusts on top of Kiel Mount (Stat.300-301). The afternoon was dedicated to another multibeam survey further upslope south-east of Kiel Mount (Stat. 302). The survey revealed a multitude of interesting features. Because of the limited time, we could only survey one area with the OFOS (Stat. 303) until mid night. This site was dominated by an elongated carbonate mound, which was partly covered with dense *Lophelia pertusa* thickets that were hitherto not reported for the western part of Rockall Bank. The new mound was named “**Franken Mound**”.

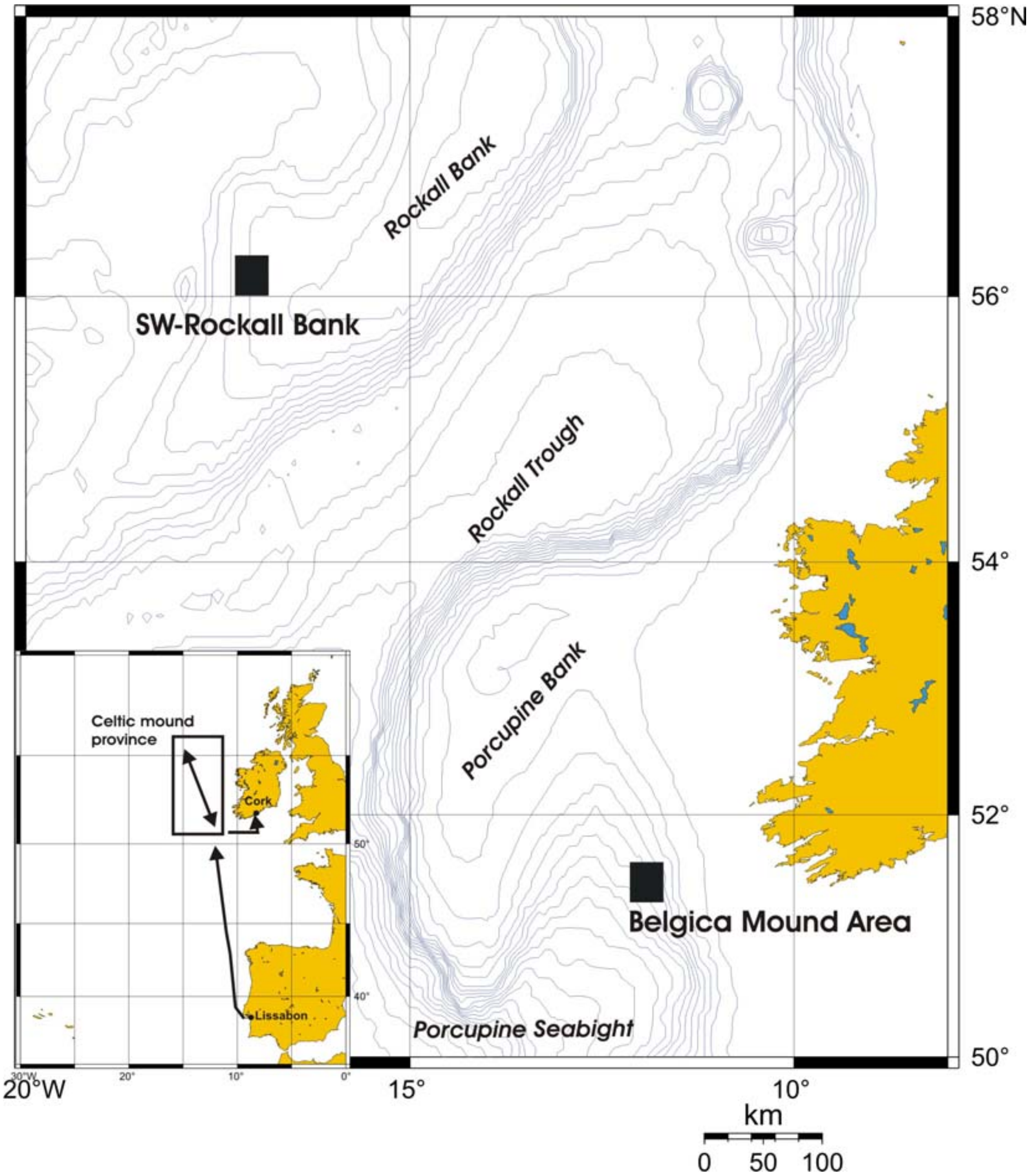



**Fig. 1.1:** Cruise tracks and working areas of Leg M61-1

Sunday 2.5.2004 - The rest of the night was dedicated to first bottom sampling in the newly surveyed sites. A series of van Veen grabs were deployed on Kiel Mount (Stat. 304-309). This was followed by box grab sampling and a gravity corer cast (Stat. 310-313). A CTD/Ro follwed at the Franken Mound (Stat. 314). The rest of the day was spent with van Veen grab sampling on Franken Mound, which was only of moderate success since the weather conditions quickly dete-

riorated from mid-day on reaching Beaufort 8. We left the station shortly before midnight and steamed back to the Porcupine Seabight area.
Monday 3.5.2004 - We continued our transit with strong gale (Beaufort 8-9) from northwest. A planned Station on Porcupine Bank had to be cancelled because of the rough sea state, which prevented gear deployments. We therefore continued our passage to Cork.
Tuesday 4.5.2004 - We continued our transit. In the meantime, winds had increased to 10 Beaufort with gusts of 12 Beaufort. In the evening R/V METEOR docked at the container dock of Cork Harbour thus finished our journey.

## 1.4 Preliminary Results

### 1.4.1 High Resolution Physical Oceanography in Relation to Mound Topography

(Dullo, W.-C., Flögel, S. and Rüggeberg, A.)

The major objective of CTD measurements during cruise M61-1 was to determine the small scale spatial variability of water masses around the carbonate mounds and deep water corals. Therefore, we conducted several series of high-resolution CTD profiles across Galway Mound and Thérèse Mound (BMP) and across Kiel Mount west of the Rockall Bank.

Another objective was to study the stable isotope composition of dissolved inorganic carbon in the water close to the seafloor, on which the benthic organisms partly rely when building their skeletons. The stable isotope composition of the bottom water will be used to calibrate temperature reconstructions using the isotope composition of the aragonite skeletons of living *Lophelia pertusa* specimens, collected within the close neighbourhood of the CTD/Ro deployments.

The Conductivity-Temperature-Depth (CTD) profiler used for investigations of the water column was a Seabird “SBE 9 plus” underwater unit and a Seabird “SBE 11 plus” deck unit. Additionally, it was equipped with a dissolved oxygen sensor and a Seabird bottle release unit including a rosette water sampler with 10l Niskin bottles. For the analysis and interpretation of the measurements, the downcast raw data were processed with “SBE Data Processing” software. For the visualisation of the data we used “Ocean Data View (mp-Version 2.0)”. The system operated reliably with the exception of station #314 where we encountered some problems with the bottle release unit and the data transfer cable onboard R/V METEOR which resulted in the loss of CTD-data below 320 m at this station due to a storage error.

A total of 40 CTD profiles has been measured in the Belgica Mound Province (Fig. 1.2–1.5) and at the western margin of Rockall Plateau (Fig. 1.6–1.8). Bottom water samples have been taken at all locations and continuous sampling throughout the water column was performed at three locations (Station #233, #283/2, #294/2).

The waters above the investigated mounds were sampled as closely as possible. We-operated seventeen CTD’s across Galway Mound (N-S and E-W transects), eight CTD’s across Thérèse Mound (N-S transect) and nine CTD’s across Kiel Mount (N-S and E-W transects). In addition, three CTD profiles (#278, #279, #280/1-2) were measured for microbiological studies (S. Neulinger), including bottom water samples for molecular biological analysis.

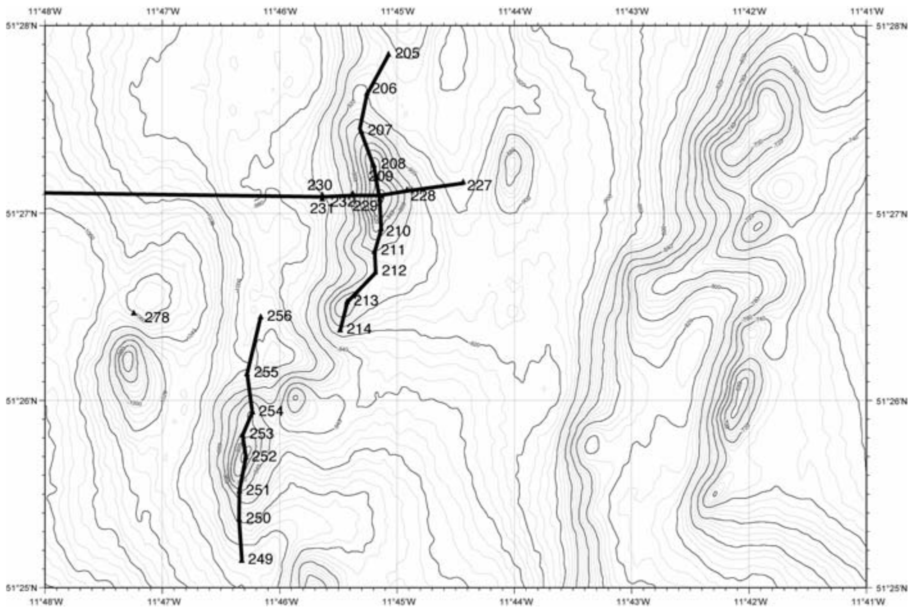



**Fig. 1.2:** Station map of CTD measurements in the Belgica Mound Province, SE Porcupine Seabight. Indicated are WE-, NS-transects across Galway Mound and NS-transect across Thérèse Mound (see Fig. 1.2 and 1.3).

**Belgica Mound Province**

The distribution of water masses is si-milar in all profiles. Temperature, sali-nity and dissolved oxygen show maxi-mum values at the surface and decrease continuously with depth (Figs. 1.3 and 1.4). A warm surface layer of 40 to 50 m depth was not established in April and May 2004 as compared to August results of R/V POSEIDON cruise 265**.** The near-surface temperature differen-ce between spring (M61-1) and sum-mer (POS 265) amounts on average 5°C. At around 650 m water depth, the oxygen content decreases rapidly to a minimum value at 1000 m, while salinity increases by 0.2 PSU.

Fig. 1.5 shows the N/S-relation of selected profiles typical for this area. The North Atlantic Central Water (NACW) exhibited a linear, uniform distribution down to a salinity mini-mum at around 700 m. The influence of the Mediterranean Outflow Water (MOW) is depicted in the slight salinity increase with maximum values of 35.6 ‰ at 1000 m water depth. This water mass is less characteristic in temperature, but shows a low oxygen content of 3.7 ml/l.

The arrangement of the CTD pro-files followed the almost S-N oriented current regime and perpendicular to it (Fig. 1.3 and 1.4). The E-W temperature profiles show a clear differentiation in a downslope and up-slope orientation (Fig. 1.3). The mounds obviously form a barrier which obstructs a mixing of the upslope and downslope bottom waters. A distinct pattern emerges in the distribution of dissolved oxygen in the bottom waters. The oxygen content between 850 and 950 m depth is higher by 0.1 to 0.2 ml/l to the north of Galway Mound than south of it. The N-S oxygen difference is considered as a significant feature. Such difference is not seen on the perpendicular E-W transect. If the effective bottom water flow is in southward direction, this pattern seems to reveal enhanced oxygen consumption at or around the top of Galway Mound. The conclusion is corroborated by the high density of the deep-water corals on top of Galway Mound that may effect locally enhanced oxygen consumption. A similar pattern is not recognized around Thérèse Mound, however.

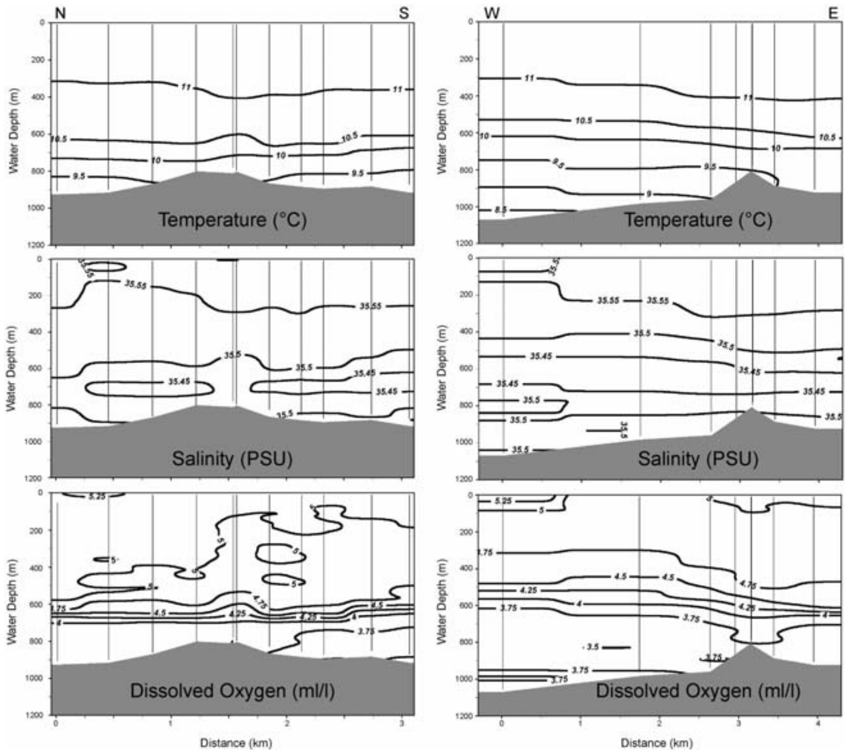



**Fig. 1.3:** EW- and NS-profiles of temperature, salinity and dissolved oxygen across Galway Mound (see transect in figure 1). MOW appears below 700 m water depth as indicated by increasing salinity and decreasing oxygen content, influencing the coral ecosystem on top of the mound.

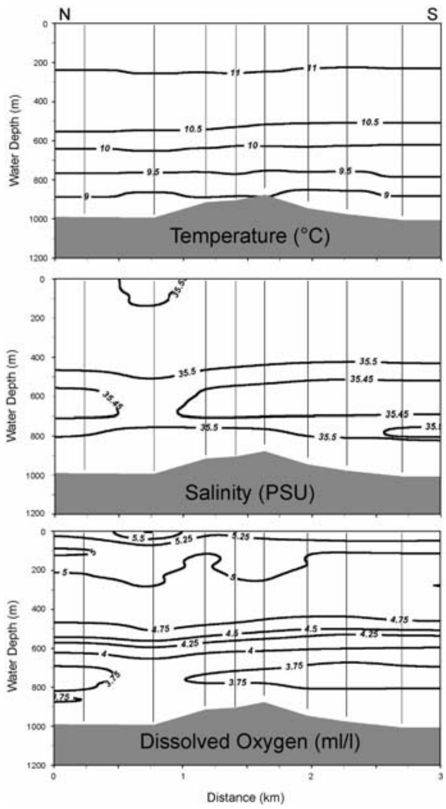



**Fig. 1.4:** NS-profiles of temperature, salinity and dissolved oxygen across Thérèse Mound (see transect in Fig. 1.2).

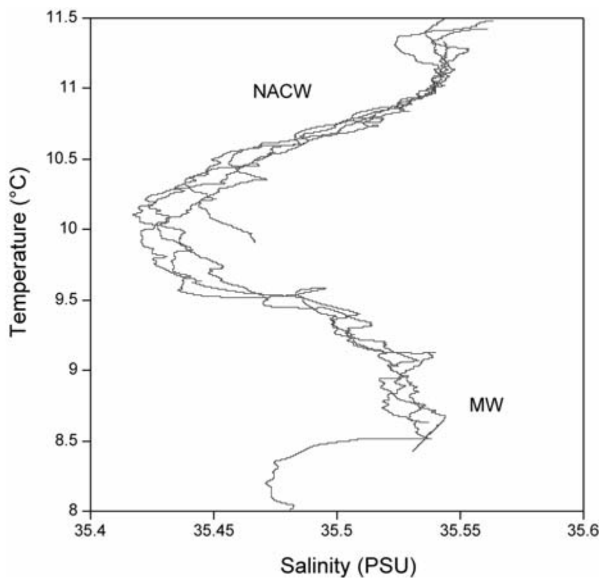



**Fig. 1.5:** TS-plot of selected profiles typical for the Belgica Mound Province.

**W Rockall Bank**

Two transects with 9 profiles were recorded west of Rockall Bank; one transect running N-S, the other in E-W direction across Kiel Mount (Fig. 1.6). The profiles of temperature, salinity and dissolved oxygen show a different distribution compared to the Belgica Mound Area. All parameters have maximum values at the surface and decrease continuously with increasing depth (Fig. 1.7). An increase in salinity is not well pronounced in water depths below 800 m suggesting an insignificant MOW advection to this area. However, the dissolved oxygen shows minimum values of 4.35 ml/l around 800 m water depth.

Figure 1.8 shows the T/S-relation of a selected profile typical for this area. The NACW exhibited a uniform distribution down to a salinity minimum at around 700 m. An influence of the MOW, if at all, is suggested in the slight increase of the salinity (35.6 units) and the oxygen minimum between 800 and 1000 m water depth.

All parameters along the E-W transect show a well-stratified water mass. Only dissolved oxygen increases below 1000 m water depth similar to the situation in the Belgica Mound Province. The N-S running oxygen section depicts much lower values south of Kiel Mount (4.15 ml/l) than in the north of the mount (4.75 ml/l). Again, such difference is not seen on the perpendicular, E-W transect (Fig. 1.7). High oxygen contents at 1200 m water depths at the northern and western foot of Kiel Mount indicate together with the OFOS-observation of current ripples on the sea floor the advection of well-ventilated Norwegian Sea Overflow Water from the North. Therefore, the N-S oxygenation difference points to substantial oxygen consumption on the southern rise of Kiel Mount. Whether this pattern is due to enhanced respiration of a denser coral thicket on the leeward side, or simply reflects a quiet zone of sluggish circulation behind Kiel Mount needs to be further investigated.

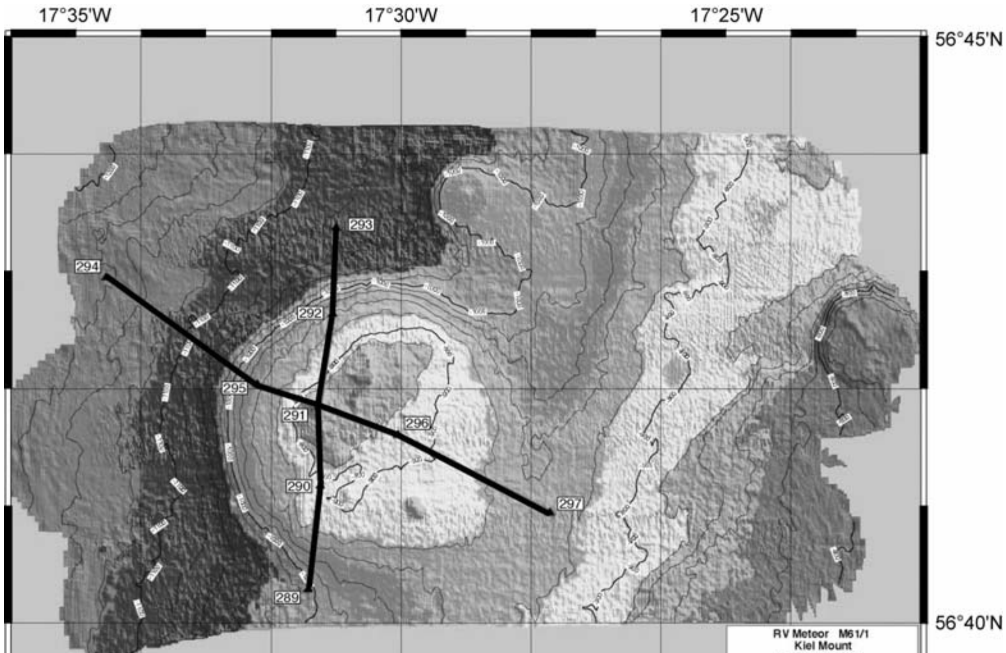



**Fig. 1.6:** Station map of CTD measurements at the western margin of Rockall Plateau. Indicated are WE- and NS-transects across Kiel Mount (see Fig. 1.7 and 1.8).

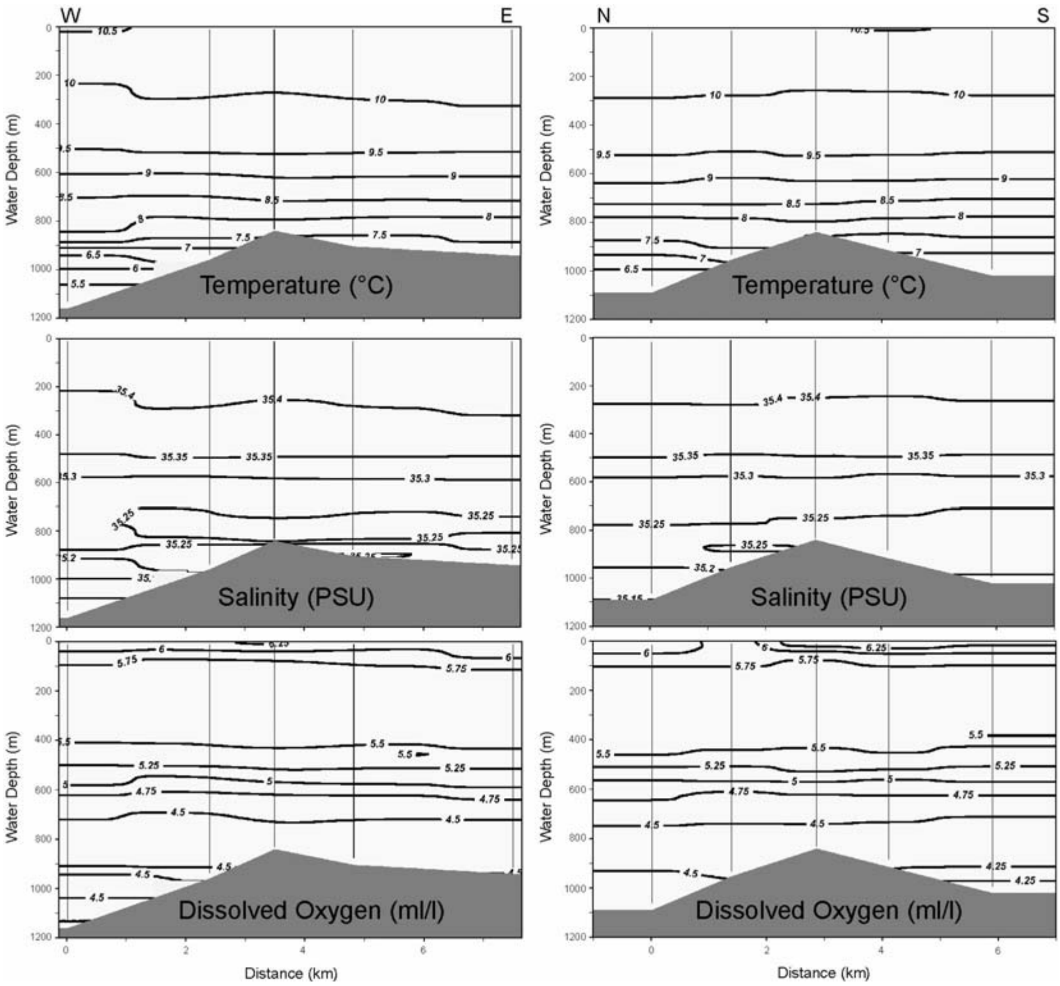



**Fig. 1.7:** EW- and NS-profiles of temperature, salinity and dissolved oxygen across Kiel Mount (see transect in Fig. 1.6).

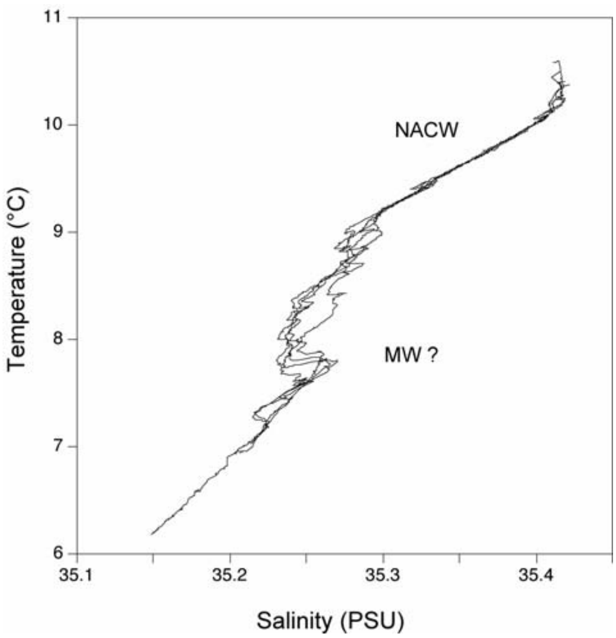



**Fig. 1.8:** TS-plot of several profiles typical for the Kiel Mount area.

### 1.4.2 The Role of Microbes in Slope Stabilisation on Deep-Sea Carbonate Mounds

(Neulinger, S.)

Microbes are ‘key players’ in mound-building processes. Indeed, prokaryotic organisms play this role since the Archaean era, and the mounds of the Porcupine Basin and Rockall Trough seem to be only the latest and long missed link of microbial carbonate formation through the ages. Many carbonate mounds in the above-mentioned provinces have rather steep-inclined flanks as compared to the slope of the continental margin in the surrounding area. The resistance of these mound flanks against slides and erosion is mainly ascribed to cemented carbonate strata or crusts on their surface. Though the formation of such carbonates is common even in the cold and deep waters of the NE Atlantic, the mechanisms and environmental factors that control this diagenetic process are currently unknown. Research experience from other settings gave rise to the hypothesis that the formation of the carbonate crusts in the Porcupine Basin and Rockall Trough is mediated by microbial activity.

In order to pursue this hypothesis of microbial calcification, several types of bottom samples were collected from on- and off-mound locations in the Porcupine Seabight, at the Porcupine abyssal plain, and at the SE-Rockall Bank for microbiological analysis: (1) soft sediment with box corer, multiple corer, and TV-grab, (2) coral debris and fossil carbonates with TV-grab, and (3) bottom water samples taken from the multiple corer and the CTD/Rosette. The substrate samples were either deep-frozen immediately for subsequent recovery of DNA and bacterial cultivation, or treated with paraformaldehyde solution to prepare them for fluorescence *in-situ* hybridization (FISH). Water samples were filtered through 0.2µm membrane filters to retain bacterial cells. The filters were conserved for DNA extraction and FISH in the same way as the substrate samples.

It was not possible to recover recent carbonate strata from mound flanks with the employed sampling gears. Actual samples of recent carbonate formations were to be collected with the ROV on leg M61-3. Thus, the samples collected on leg M61-1 served as references in genetic analysis and cultivation experiments.

### 1.4.3 OFOS-Surveys in the Belgica Mound Province and Western Rockall Bank: First Results

(Freiwald, A., Beuck, L., Linke, P., Pfannkuche, O., Bannert, B.)

Ground-thruthing operations were carried out with the IFM-GEOMAR OFOS-camera sledge during M61-1. This visual inspection of cold-water coral environments in the bathyal zone addresses various scientific and socio-economic themes that are centred around sedimentary geology, benthic biology, and mapping of biological resources. The latter aspect has become a major matter of concern on many political agendas that are related to the protection of cold-water coral ecosystems and to mitigate unsustainable human fishing activities (Freiwald et al. 2004).

The OFOS scientific objectives were:

- To describe the sedimentary environment of carbonate mounds and the adjacent seabed (facies analysis).

- To map the benthic habitats and species distribution of the megafauna (these data will be further analysed for detailed thematic maps demonstrating biological diversity, biomass, carbonate production, coral densities, etc.).
- To document demersal fish and other exploitable organisms of economic importance.
- To document and to quantify human activities in cold-water coral ecosystems (e.g., trawling impact, lost fishing gear, scientific sampling, etc.)

OFOS surveys were carried out in the Belgica Mound Province (BMP) and a poorly explored sector at the deeper western Rockall Bank (WRB) margin totalling in 7 photo-transects with 980 underwater colour slides of which 961 are of excellent quality (98%). The film used was a KODAK Ektachrome 400 (27 DIN) colour slide. The downward looking camera system was adjusted with its optics, illumination and bottom weight distance indicator to 1.50 m above the seabed. An image taken at 1.50 m above the seabed shows an area of c. 1.10 by 1.75 m, or c. 1.925m$^2$. In addition, three equally spaced laser dots (50 cm) form a discrete triangle for scaling of objects. The online video camera mounted on the OFOS sledge provided black & white images due to the ship's-owned coaxial cable that did not allow transmission of a colour generated video signal. Onboard data-storage of the video documentation happened in three different ways: (1) continuous recording on VHS-tapes, (2) selected recording on a digital mini-DV tapes, and (3) a digital recording system linked up with the ADELIE video-tracking and protocol software package. The navigational maps used for the OFOS dives in the BMP based upon a multibeam map data set generated by RV Polarstern in 2000 (Beyer et al., 2003). This data set was kindly passed over by the Alfred Wegener Institute, Bremerhaven, to the OFOS planning team of M61-1. Navigation in the poorly explored WRB area was facilitated through data exchange with the Geological Survey of Ireland (GSI), who mapped the entire WRB during the past two years. The high resolution maps of two target areas in the WRB area were produced with R/V METEOR's HYDROSWEEP and PARASOUND systems.

#### 1.4.3.1 OFOS-Dives in the Belgica Mound Province (BMP)

(Freiwald, A., Beuck, L., Linke, P., Pfannkuche, O., Bannert, B.)

Previous multidisciplinary research cruises to BMP proved the existence of 64 mounds of which about 20 are buried by sediment drift (De Mol et al. 2002). The BMP mounds cluster in two ridges at 700 and 900 m depth of a major contourite channel (Van Rooij et al. 2003). The M61-1 OFOS dives were concentrated on mounds that were not explored before (Fig. 1.9). These are two mounds belonging to the deeper mound ridge: Castor and Pollux, and one mound located in an intermediate position between the deeper and shallower ridge: Erik Mound. One buried mound, Joe‘s Nose, was documented as an example from the shallow mound ridge.

##### 1.4.3.1.1 Castor Mound: OFOS Dive 1 (M61-1-203)

(Freiwald, A., Beuck, L., Linke, P., Pfannkuche, O., Bannert, B.)

The Castor Mound is the deepest and westernmost mound in the northern BMP. It is located south of a pronounced gulley feature that continues upslope where it intersects between the Galway Mound and the Therese Mound. The mound has an ovoid shape measuring c. 1000 m in NS-direction. The summit is positioned in the northern part of the mound, thus resulting in an asymmetric topography with a steeper northern slope and a less inclined southern slope.

The c. 1200 m-long Castor Mound survey started in a gulley due north of the mound at c. 1067 m depth. With a southerly heading, OFOS was towed over the steeper northern slope and passed the summit of Castor at c. 950 m. It went further down along the southern slope. The dive ended at 1025 m depth. Five major facies were recognised along the dive track (see Fig. 1.10):

Facies A Rippled sand with low-relief coral ridges

Facies A is only developed along the base of the southern flank from 1025 – 1015 m depth. Mobile sand sheets are intensely rippled by the strong tidal currents. The ripple troughs are filled with pteropod tests. The ripple marks are deflected around sparsely occurring coral frameworks or coral rubble accumulations. The mobile sand sheets show no signs of ‘Lebensspuren’, or semi-infaunal organisms, thus indicating a highly dynamic environment. Benthic life concentrates on the almost dead coral colonies or rubble, which is arranged in contour-parallel ridges with low relief (> 30 cm). The lateral distance between the ridges varies between 6 and 15 m. Large antipatharian colonies *(Parantipathes* sp.) are rooted within the coral framework.

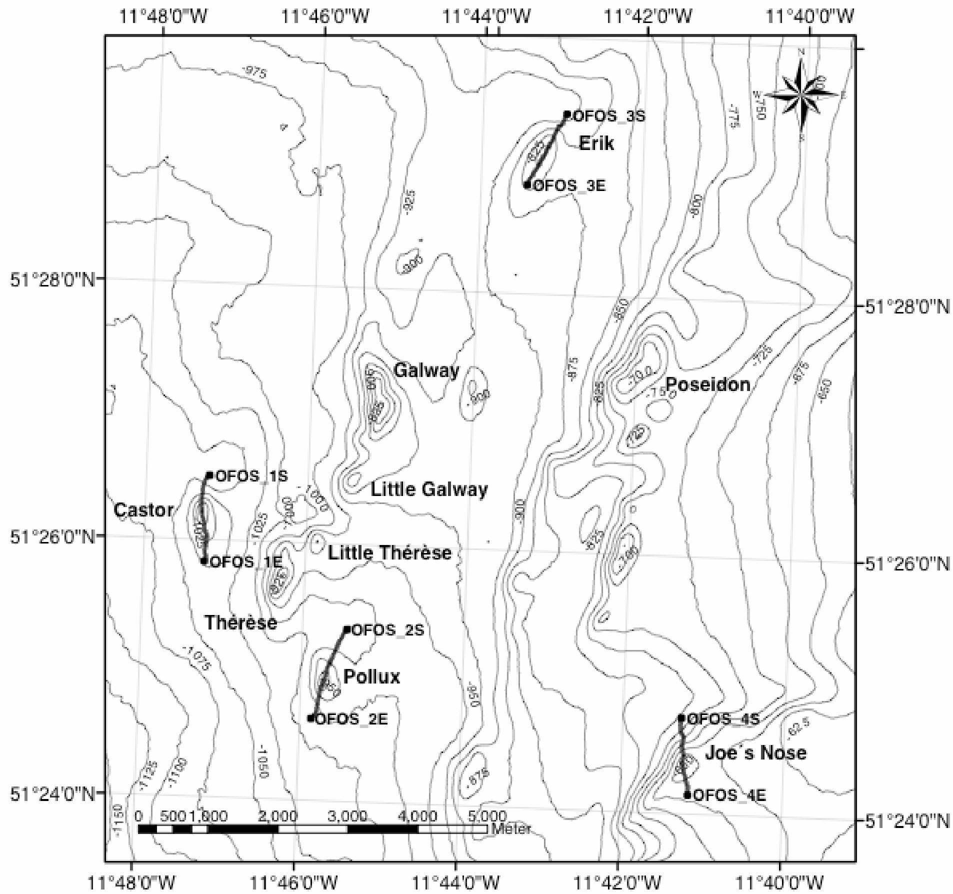



**Fig. 1.9:** Overview of the four OFOS dives in the BMP area.

Facies B Rippled sand with high-relief coral ridges

Facies B is similar to facies A but the size and height of the coral ridges turned from low to a high relief, up to 1 m thick. The ridge shows an almost complete cover of live and dead coral colonies *(Madrepora oculata, Lophelia pertusa),* anthipatharians, actinians and hexactinellid sponges. The coral colonies extended over ridges and therefore, the mobile sand sheet areas become smaller upslope. Facies B is developed along the southern slope from 1015 – 1003 m but is the dominating facies along most of the southern slope from 1036 – 950 m near the summit.

Facies C Coral thickets

Facies C is a continuation of facies B but the ridged topography becomes gradually hidden under an almost complete cover of coral colonies. The thickness of the coral cover is variable from a few centimetres to almost 1 m. Living corals grow upon dead and often degraded colonies. This facies, which is only present at the middle southern slope (1003 – 988 m), shows some faunal peculiarities. Dense clusters of gorgonian colonies *(Acanthogorgia armata*) are only found here (Fig. 1.11). Dead coral framework is intensely colonised by a red coloured hormatiid anemones which have been found so far only in the Pelagia Mound Province, western Porcupine Bank margin (Fig. 1.11). The false boarfish *Neocyttus helgae* was frequently observed among the corals. During previous ROV inspections in the BMP and Rockall Trough mound provinces this

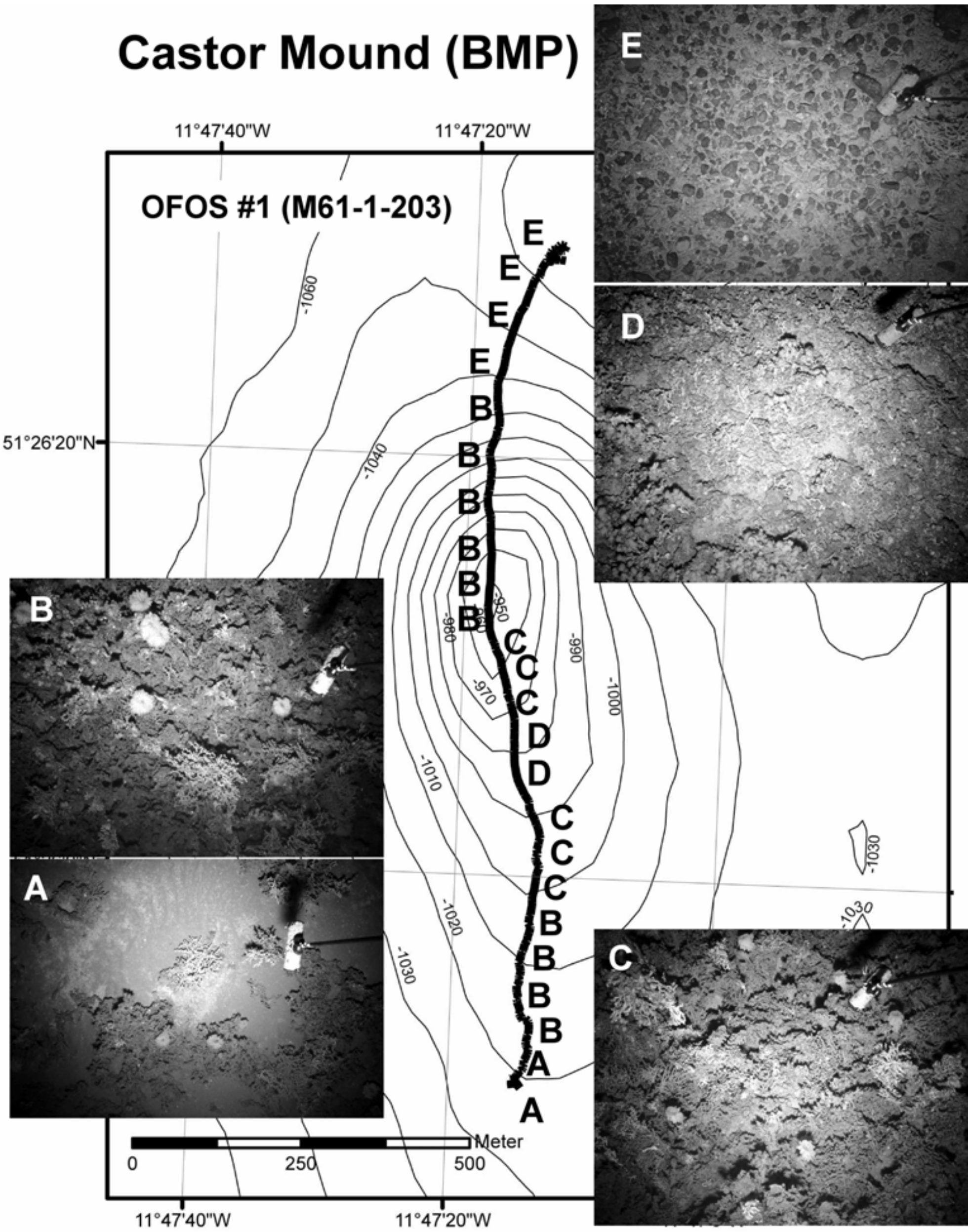



**Fig. 1.10:** Facies interpretation of OFOS-Dive #1 over Castor Mound in the BMP: A = Rippled sand with low-relief coral ridges; B = Rippled sand with high-relief coral ridges; C = Coral thickets; D = Coral rubble, E = Dropstone pavements with dispersed corals. The ground weight with a length of 20 cm can serve as a scale bar.

fish has been observed on mounds, which are affected by strong currents (Freiwald, pers. observation). This coral thicket occurrence is the richest one mapped with OFOS during M61-1 in the BMP area.

Facies D Coral rubble

Near the summit of the upper southern slope, facies D, a coral rubble area is developed at 988 – 950 m depth. The corals are strongly fragmented and broken. The red coloured hormatiid anemone still occurs abundantly within this subhabitat. It is difficult to explain the existence of a large coral rubble facies near the crest of a mound. Generally, this area is known to harbour the densest live coral occurrences elsewhere in the BMP. Although very speculative at this point, it is tempting to conclude that this area was affected by fishing gear a while ago, that flattened the coral thicket completely.

**Fig. 1.11:** Gorgonian forest consisting of *Acanthogorgia armata* in the coral thicket facies (above). Dense accumulation of a red-coloured hormatiid anemones (arrows) in the coral thicket and coral rubble facies at the southern slope (below). The ground weight with a length of 20 cm can serve as a scale bar.

Facies E Dropstone pavements with dispersed corals

Facies E can be related to the gulley feature that is developed at the northern end of Castor Mound. It is documented from 1038 to at least 1037 m depth and consists of dropstone pavements and occasionally, dead coral framework or rubble. The dropstones are polymict in composition and comprise granites, black shales, and limestones both rounded and angular in shape and from pebble to boulder sizes. They are colonised by a discrete fauna consisting of brachiopods, encrusting holothurians *(Psolus squamatus)* and stylasterids *(Pliobothrus symmetricus).*

### 1.4.3.1.2 Pollux Mound: OFOS Dive 2 (M61-1-204)

(Freiwald, A., Beuck, L., Linke, P., Pfannkuche, O., Bannert, B.)

The Pollux Mound also belongs to the deeper mound ridge in the BMP but is slightly shallower than Castor Mound (see Fig. 1.9). It is ovoid in shape with a 1000 m-long long axis in NNW-SSE orientation. The base is at 990 m and the centrally positioned summit is at 908 m water depth. The steepest flank occurs at the western side and the least inclined flank is oriented to the southeast. During the 1000 m-long OFOS dive, starting in the NE of the mound and, after crossing the summit, ending on the SW-flank, four major facies have been found (Fig. 1.12).

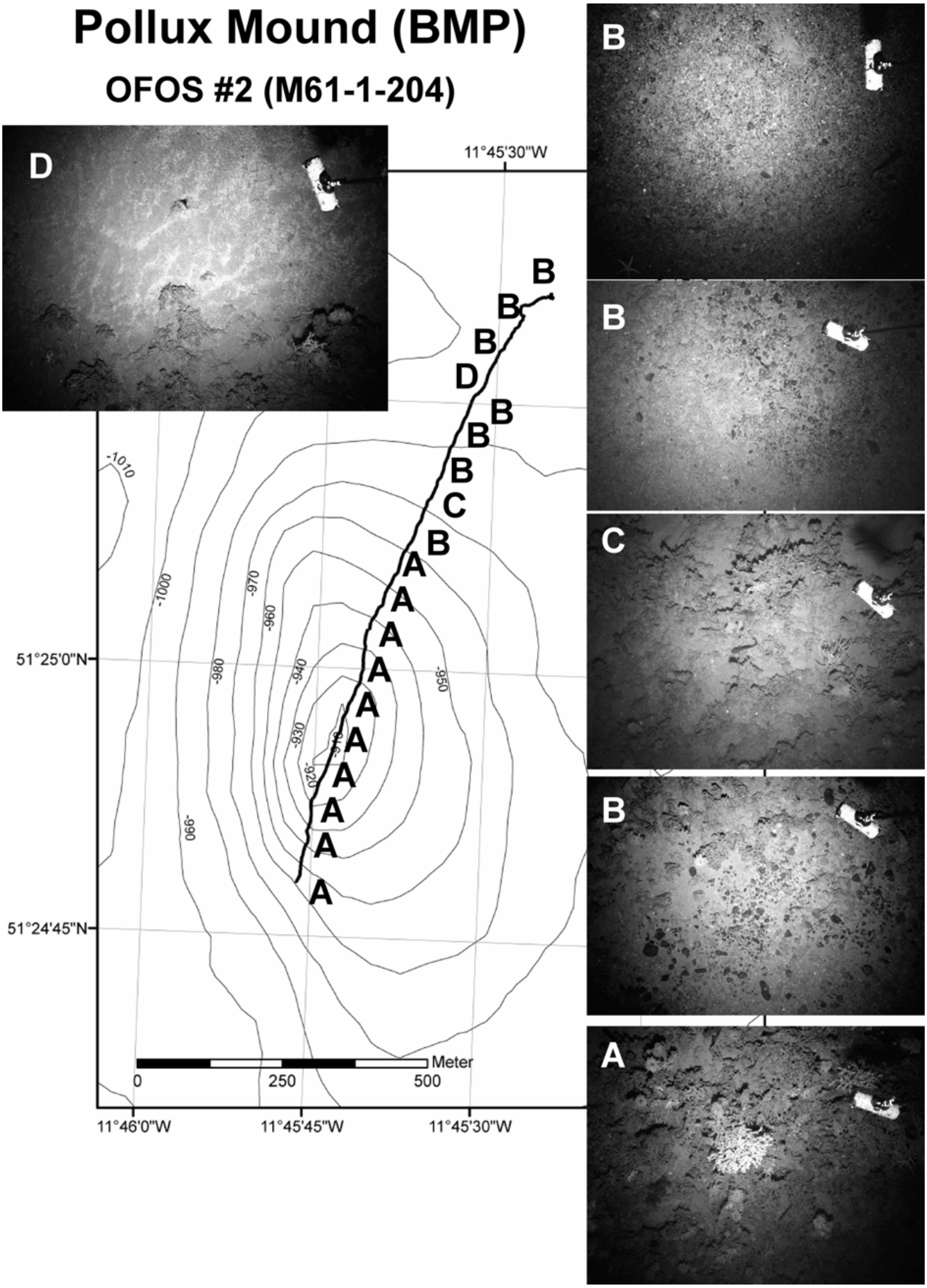



**Fig. 1.12:** Facies interpretation of OFOS-Dive #2 over Pollux Mound in the BMP:

A = Sand with high-relief coral thicket ridges; B = Dropstone pavements, rippled sand sheets; C = Coral rubble; D = Rippled sand sheets with low-relief coral ridges. The ground weight with a length of 20 cm can serve as a scale bar.

Facies A Sand with high-relief coral thicket ridges

Along the OFOS-track, almost the entire mound surface on both sides of the summit is characterised by the same facies type. Sandy areas interrupted by high-relief ridges, which are overgrown by (mostly dead) coral colonies, are developed from c. 960 to 908 m depth on both flanks mapped. Living corals occur much less in quantity than on Castor Mound. *Aphrocallistes bocagei,* antipatharians and the purple octocoral *Anthothela grandiflora* grow abundantly within the coral thickets. Two lost nets were found in this coral environment.

Facies B Dropstone pavements, rippled sand sheets

This facies is confined to the deeper northeastern slope (>965 m) and becomes steadily prominent towards the gulley. The sedimentary environment is quite heterogenous as it changes within short distances from dropstone pavements to mobile, rippled sand sheets and dispersed coral rubble. Nearly no living colonial corals were documented here. Dead coral frameworks and coral rubble areas show a random distribution. Larger dropstones often are colonised by *Parantipathes* sp. In the gulley, the small stylasterid *Pliobothrus symmetricus* dropstones is frequently attached to the mostly pebble and cobble-sized dropstones. A large lost net was found in the central part of the gulley.

Facies C Coral rubble

A larger coherent coral rubble area was noted only on the northeastern slope at 968 – 975 m. Locally, degraded and partly sediment-covered coral thickets were mapped. Live colonial corals occur very rare (1 per $m^2$ to a maximum) and are less than 20 cm high, thus indicating occasional larval settlement. *Aphrocallistes bocagei* and antipatharians were encountered at greater quantities within this environment.

Facies D Rippled sand sheets with low-relief coral ridges

Facies D forms a gradual downslope continuation of facies C. Rippled sand sheets migrate between low-relief coral thicket and rubble ridges.

Apparently, the facies differentiation on Pollux Mound itself is much less diverse compared to Castor Mound. The coral thickets are less dense and a higher ratio of dead vs. life corals can be noted for the Pollux Mound. Also the red-coloured hormatiid anemones are lacking on Pollux.

#### 1.4.3.1.3 Erik Mound: OFOS Dive 3 (M61-1-247)

(Freiwald, A., Beuck, L., Linke, P., Pfannkuche, O., Bannert, B.)

Erik Mound is the northernmost structure studied in the BMP and is situated in an intermediate position between the deeper and almost buried mounds of the shallower upslope ridge. The shape is highly ovoid with almost symmetric contour lines. Only the northeastern slope is somewhat steeper than the opposing southwestern slope. The western flank starts at 900 m, whereas the eastern flank is shallower, with 870 m respectively (see Fig. 1.9). The NE-SW-striking long axis of Erik Mound measures 1300 m. The OFOS-dive #3 followed this orientation, starting at 904 m in the northeast and ending after 950 m at 845 m. Only three major facies types were discerned from the photographic documentation (see Fig. 1.13).

Facies A Coral rubble with sand cover

Facies A dominates the entire upper slope and summit area on Erik Mound with no further major differentiation from 855 m to the summit at 818 m. Coral thickets are very rare and relatively small-scaled in lateral extension. Only isolated living *Lophelia* and *Madrepora* colonies were observed. The coral rubble cover is very thin so that the muddy and sandy background sediment becomes visible. *Aphrocallistes* and antipatharians occur in much lesser abundance compared to the previously discussed deeper mounds. Larger muddy sand areas are inhabited by *Cerianthus* sp. A small exposure of facies A occurs downslope in the northeast between 870 and 882 m, where the coral rubble is associated to rippled sand sheets.

Facies B Coral rubble with dropstones

Facies B was detected only along the northeastern slope from 845 – 870 m. Coral rubble is associated with dropstone-rich seabed. Larger dropstone boulders are colonised by barnacles.

Facies C Dropstone pavements

From 880 m downslope, a dropstone pavement facies is developed in the northeastern off-mound area. Stylasterids *(P. symmetricus)*, brachiopods and barnacles contribute to the carbonate sedimentation in this erosional environment.

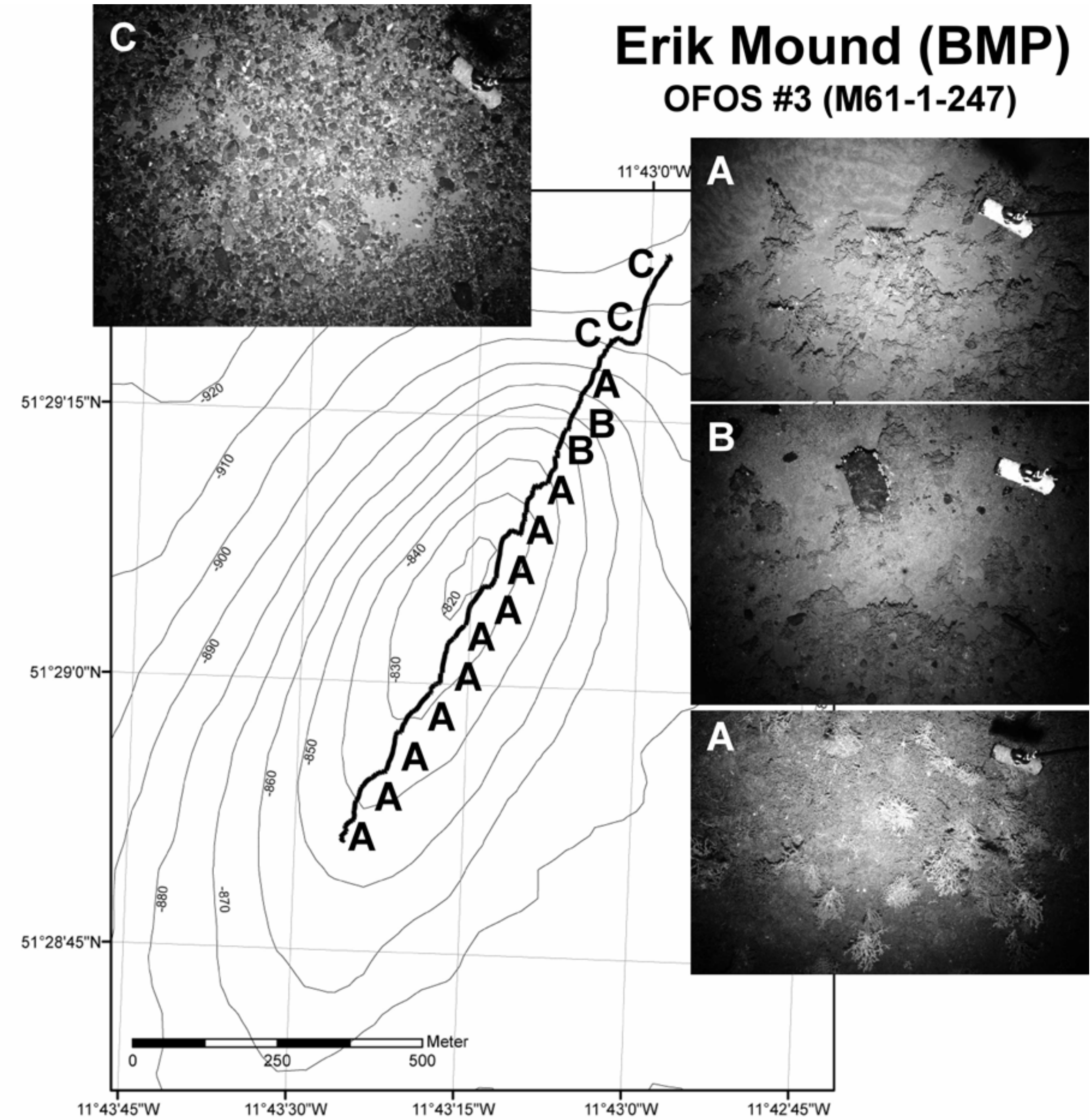



**Fig. 1.13:** Facies interpretation of OFOS-Dive #3 over Erik Moind in the BMP: A = Coral rubble with sand cover;B = Coral rubble with dropstones; C = Dropstone pavements. The ground weight with a length of 20 cm can serve as a scale bar.

#### 1.4.3.1.4 Joe´s Nose: OFOS Dive 4 (M61-1-248)

(Freiwald, A., Beuck, L., Linke, P., Pfannkuche, O., Bannert, B.)

Joe’s Nose marks a prominent c. 140 m-high escarpment within the otherwise gently inclined sedimentary drift packages of the western Irish margin (see Fig. 1.9). The reason for the existence of this remarkable structure is a buried carbonate mound and the very steep westerly-faced slope marks its former flank. This nose was inspected visually using the VICTOR 6000 ROV during the R/V POLARSTERN Cruise ARK-XIX/3a in 2003. According to the results, lithified carbonates of unknown origin and composition are cropping out on top of this structure at 632 m depth. The TV-Grab (M61-1-260) from this area yielded some pieces of a bathyal coral limestone. OFOS dive #4 started at 770 m in the northern gulley and headed south over the top plateau. This plateau, on which the OFOS-track ended at 668 m, gently dips SSE-ward. Five major facies were reflect the morphological complexity of this 1100 m-long transect (Fig. 1.14).

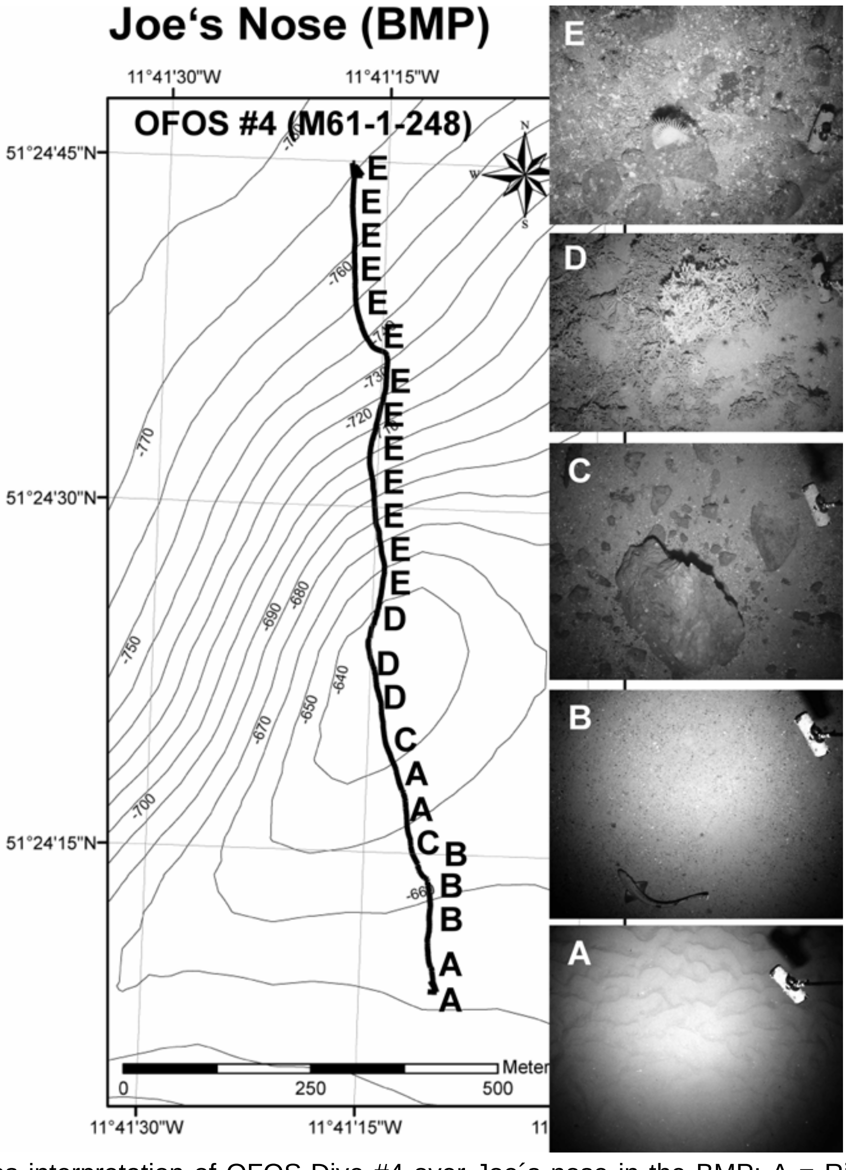



**Fig. 1.14:** Facies interpretation of OFOS-Dive #4 over Joe´s nose in the BMP: A = Rippled sand; B = Dropstone-littered sand; C = Barnacle plate-rich sands with dropstones; D = Coral rubble and thickets; E = Dropstones with barnacle plates and coral rubble. The ground weight with a length of 20 cm can serve as a scale bar.

Facies A Rippled sand

Facies A was documented two times on the gently dipping plateau of Joe‘s Nose: one area some distance away from the top at 665 – 668 m and one area closer to the top at 642 – 650 m. The muddy sands are accentuated by sinuous ripple marks, and occasionally, sand waves occur.

Facies B Dropstone-littered sand

Facies B consists of an even coarse sand sheet, rich in pebble-sized dropstones. Dropstone boulders are scattered throughout this environment. The boulders are surrounded by haloes of cobble-sized dropstones and shell hash. Demersal fish and sharks were frequently encountered, such as *Galeus melastomus, Helicolenus* sp. and *Lepidion eques*. The epibenthos is rather scarce, except for some cerianthids. Mobile epibenthos is dominated by decapods *(Paromola cuvieri).*

Facies C Barnacle plate-rich sands with dropstones

Facies C was encountered near the top of the plateau at 655 – 650 m and 642 – 636 m. Due to the presence of larger dropstones, the coarse sandy seabed is covered by barnacle plates, which had been fallen down after the death of the barnacles occupying the dropstone surfaces (Fig. 1.15). Most likely the barnacles belong to *Bathylasma cf. hirsutum*, a widespread bathyal element in the NE Atlantic (Gage, 1986).

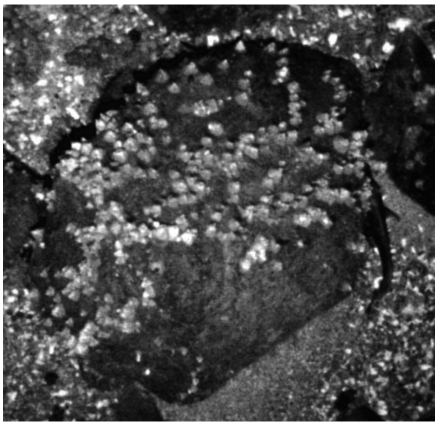


**Fig. 1.15:** A dropstone boulder from the plateau of Joe’s Nose (Facies C), plastered with *Bathylasma* cf. *hirsutum* at 640 m depth.

Facies D Coral rubble and thickets

The top of Joe’s Nose at 632 to 635 m is the place where coral thickets and coral rubble occurs. The coral thickets consist of almost dead but still exposed coral frameworks with few live *Madrepora oculata* colonies. The underlying hardsubstrate is an outcropping Pleistocene bathyal limestone, that forms stratified outcrops especially at the top of the steeply inclined escarpment. Few lost nets were encountered in this area.

Facies E Dropstones with barnacle plates and coral rubble

The entire northern slope of Joe’s Nose is characterised by facies E from 630 – 770 m. The slope is plastered by dropstones of all size classes and is littered with barnacle plates and locally, with coral rubble. Strong currents prevent settling of fine-grained sediments, thus sustaining this filter-feeding community. The anemone *Phelliactis hertwegii* was frequently observed on larger dropstones.

To conclude, there is an apparent decrease of living coral percentages from the deep Castor Mound to Joe’s Nose. However, in the recent past, ecological conditions must have been better to sustain coral thickets even in these shallower areas. The gulleys act as conduits for tidally amplificated currents and therefore, no sedimentation except barnacle plates and brachiopods, has occurred since the deposition of the dropstones.

### 1.4.3.2 OFOS-Dives at the Western Rockall Bank (WRB)

(Freiwald, A., Beuck, L., Linke, P., Pfannkuche, O., Bannert, B.)

During M61-1 a new coral province was studied at the deeper margin of the WRB. Previous information on promising topographic features as candidates for coral ecosystems were provided through the seabed mapping programme of the entire Irish exclusive economic zone by the Geological Survey of Ireland. Limited time and gale warning allowed only a 2.5 days reconnaissance that, however, yielded numerous surprising results that were broadened during the succeeding M61-3 cruise. The global databank of *Lophelia pertusa* and *Madrepora oculata* by Freiwald et al. (2004) shows no occurrences known to science prior to M61-1. However, existing knowledge of the ecological demands and the water mass properties in this new area, made it very much likely to discover new coral ecosystems.

The first seabed feature analysed was a conical submarine volcanic cone at 1100 to 900 m depth that we named as Kiel Mount (Fig. 1.16). Volcanic structures in this particular area are poorly studied but are probably of Paleogene age. The Kiel Mount was mapped with two OFOS transects which covered the plateau-like summit as well as the northern and southern slopes.

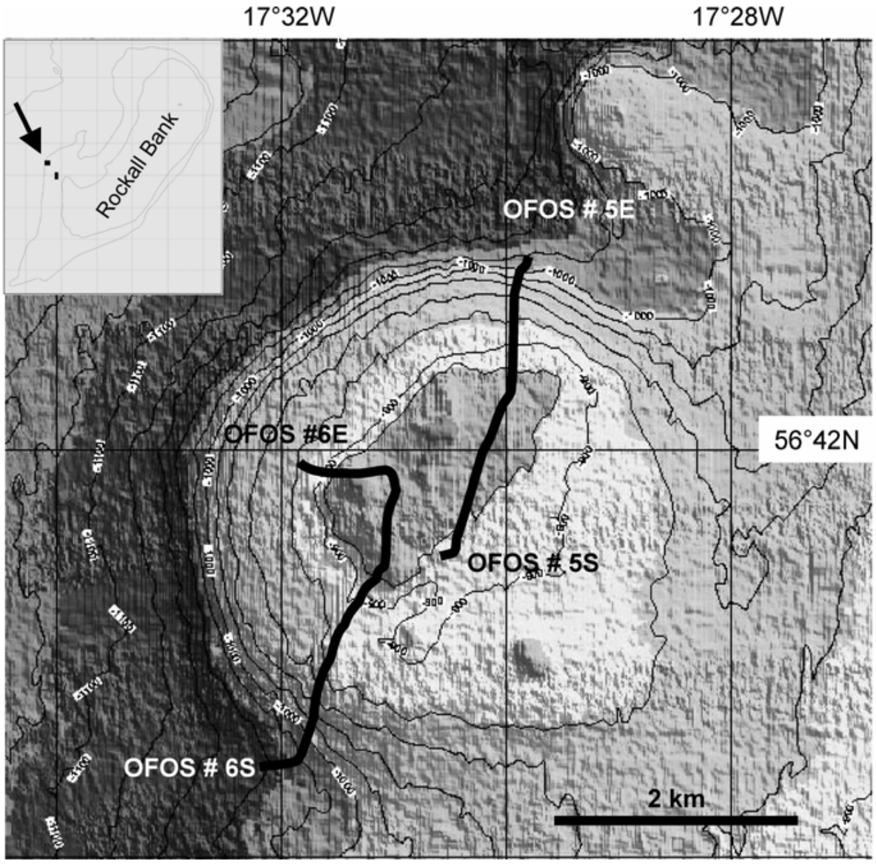



**Fig. 1.16** The bathymetry of the Kiel Mount volcanic cone at the WRB (see arrow in the inserted map of the Rockall Bank for overview) was generated with the ship-based Hydrosweep. The tracks of the two OFOS dives are indicated.

#### 1.4.3.2.1 Kiel Mount: OFOS Dive 5 (M61-1-287)

(Freiwald, A., Beuck, L., Linke, P., Pfannkuche, O., Bannert, B.)

OFOS Dive # 5 started in the deep gulley north of Kiel Mount at 1067 m and ended after 2.4 km on the central part of the summit at 902 m. Seven different facies types were encountered on this transect (Fig. 1.17):

Facies A Sand with pebbles and boulders

Facies A is restricted to the gulley in the north at 1067 – 1050 m. The sediment is a winnowed lag of a mixture of volcanoclastics and dropstones with thin veneers of sand sheets in between. Boulders are densely colonised by antipatharians, isidiid corals, encrusting holothurians *(Psolus* sp.) and large fossil stylasterid colonies *(Stylaster* sp.). Rarely, small colonies of live *Madrepora oculata* and the red-colour variety of *Paragorgia arborea* occur. The presence of the false boarfish *Neocyttus helgae* indicates a strong current regime.

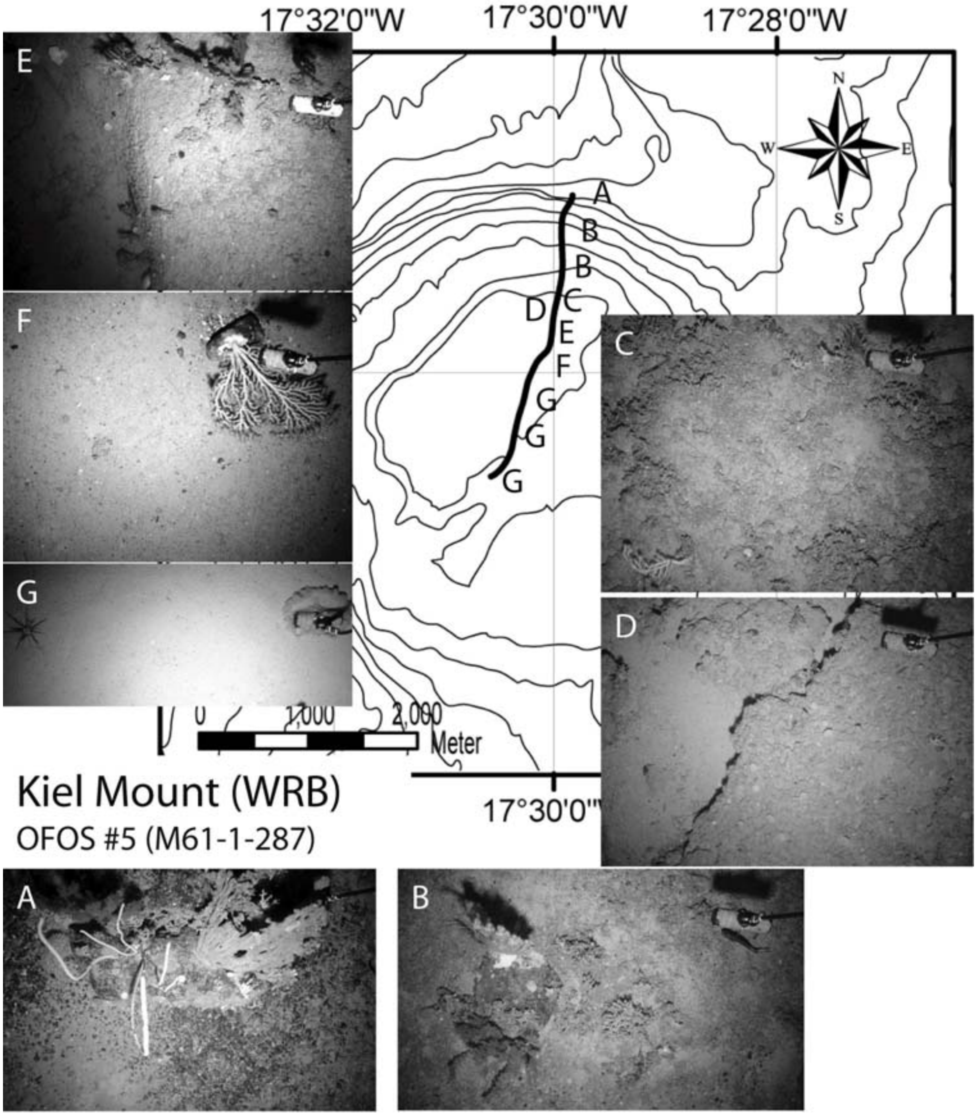



**Fig. 1.17:** Facies interpretation of OFOS-Dive #5 over Kiel Mount in the WRB area:
A = Sand with pebbles and boulders; B = Coral rubble with pebbles and boulders; C = Coral rubble with muddy sand; D = Crusts and coral rubble; E = Basalt ridge; F = Pebbly sand; G = Bioturbated muddy sand. The ground weight with a length of 20 cm can serve as a scale bar.

Facies B Coral rubble with pebbles and boulders

Facies B continues upslope of facies A up to about 900 m. The pebbly and bouldery substrate is increasingly paved with coral rubble *(L. pertusa, M. oculata).* Live *M. oculata*, *Acanthogorgia armata* and the white colour variety of *P. arborea* became more abundant. *Molva dypterygia* was frequently observed resting on the coral rubble.

Facies C Coral rubble with muddy sand

Facies C was detected only on the outer rim of the summit from 900 to 850 m, where coral rubble is admixed with muddy sand.

Facies D Crusts and coral rubble

At about 850 m, underwashed crusts of unknown origin (basaltic or carbonate source rocks?) became a prominent feature on the summit of Kiel Mount. These crust substrate provides a habitat for a variety of cnidarians such as *P. arborea* (red colour variety), isidiid corals, *Parantipathes sp*., whip corals and *M. oculata*. The crusts are littered with coral rubble of thickly calcified *L. pertusa* and *M. oculata*. Crinoids clinged on almost all cnidarian colonies. Again, *N. helgae* indicates a vigorous current regime.

Facies E Basalt ridge

Basalt outcrops are prominent on the highest areas of the summit shallower than 850 m on Kiel Mount. This substrate is rich in cnidarian colonies except for scleractinians and sponges such as *Phakellia* sp.

Facies F Pebbly sand

Facies F followed the basalt ridges towards the central part of the summit and is characterised by pebbly sand and occasional large basalt and/or dropstone boulders. The sand substrate is frequently inhabited by reddish colonies of *Pennatula* sp., whereas on the boulders live *M. oculata, P. arborea,* isidiid corals, antipatharians and the stylasterid *Pliobothrus symmetricus* are very common.

Facies G Bioturbated muddy sand

The wide central plateau of the summit is covered by bioturbated muddy sand rich in ‘Lebensspuren’. The soft substrate is inhabited by the echiurid *Bonellia viridis*, cerianthids, the actinian *Bolocera tuediae*, echinoids and the holothurian *Benthogyne* sp.

### 1.4.3.2.2 Kiel Mount: OFOS Dive 6 (M61-1-288)

(Freiwald, A., Beuck, L., Linke, P., Pfannkuche, O., Bannert, B.)

The second OFOS dive on Kiel Mount covered the southern flank at 1060 m, crossed another rough basalt outcrop terrain at 833 m and turned west to descend at the upper western slope down to 928 m. Five different facies can be differentiated (Fig. 1.18)

Facies A Coral rubble, sand and dropstones

Facies A was encountered specifically at the upper slopes of Kiel Mount and on a small area on the summit plateau. The sediment is made of a mixture of coral rubble, coarse sand and dropstones at various degrees. The sand sheets are inhabited by *Pennatula* sp., *Capnella*-like alcyonarians, *Benthogyne* sp. (holothurian) and echinoids. Dropstone boulders are colonised by *P. arborea* (white colourmorph), isidiid corals, *Parantipathes* sp. and demosponges such as *Phakellia* sp.

Facies B Bioturbated sand

Facies B occurs preferably on the summit as a lateral variation of facies A but without coral rubble and much fewer dropstones. The sand is rich in 'Lebensspuren' and cerianthids.

Facies C Basalt outcrop with thin sand veneers

Basalt crops out on the summit and frequently along the upper slope of Kiel Mount. Very often, a thin veneer of sand is deposited on the basalt basement. In larger depressions, sand infills prevail an attractive substrate for ophiuroid aggregations. The basalts are colonised by antipatharians, *P. arborea* (red colourmorph) and numerous sponges.

Facies D Coral rubble with crusts

Facies D is characterised by underwashed crusts of either basaltic or carbonate origin and was detected on a sharp edged exposure at the upper southern slope. The crusts are locally littered with coral rubble and are intensely colonised by various antipatharian species, demosponges, crinoids and ophiuroids. This area was very rich in different fish species, such as *Neocyttus helgae*, *Nezumia equalis*, *Lepidion eques* and *Trachyscorpia cristulata.*

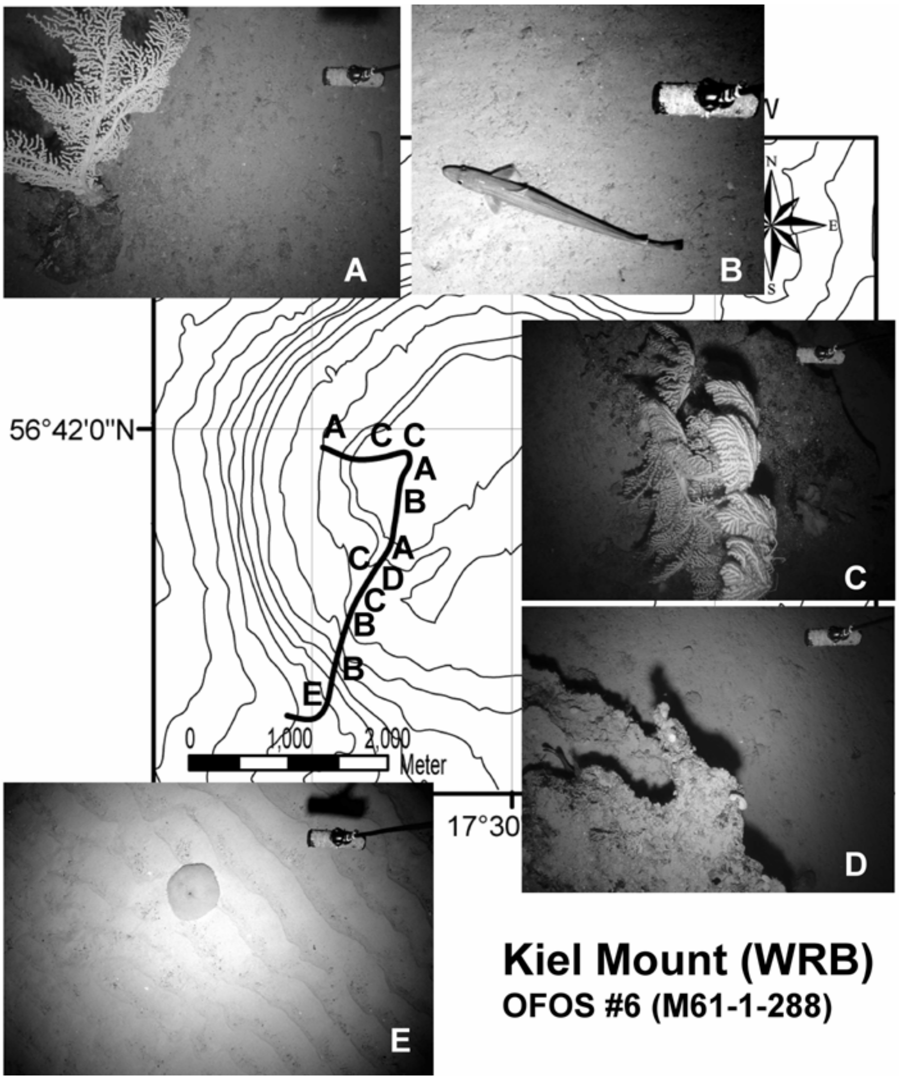



**Fig. 1.18:** Facies interpretation of OFOS-Dive #6 over Kiel Mount in the WRP area: A = Coral rubble, sand and dropstones; B = Bioturbated sand; C = Basalt outcrop with thin sand veneers; D = Coral rubble with crusts; E = Rippled sand. The ground weight with a length of 20 cm can serve as a scale bar.

Facies E Rippled sand

Facies E occurs along the deep and gently inclined foot of the southern slope. The rippled sand is sparsely inhabited with echinoids and hermit crabs.

To conclude, Kiel Mount is not very rich in live scleractinians but extremely rich in antipatharians, gorgonians, and sponges. We have never encountered so plenty of fish and holothurians on the sand bottoms. No signs of lost fishing gear argue for this observation.

### 1.4.3.2.3 Franken Mound: OFOS Dive 7 (M61-1-303)

(Freiwald, A., Beuck, L., Linke, P., Pfannkuche, O., Bannert, B.)

Franken Mound is a sedimentary structure 15 nm southeast of Kiel Mount but is situated in a mid-slope position of the WRB (Fig. 1.19). The shape is rather unusual compared to the coral-covered carbonate mounds in the BMP, which are marked by elongated and ovoid circumferences. Franken Mound has an irregular curved shape with the convex side pointing upslope to the east and an irregular surface topography with lots of smaller summits and depressions. The entire structure measures c. 2.5 km in length, with a base at around 700 m to the west and 660 m to the upslope east. The shallowest summit is at 627m. Due to a gale, we were not able to recover any seabed sample from Franken Mound and therefore, the facies description is based upon the interpretation of OFOS-dive #7 only. Three major facies were encountered during the 2 km-long OFOS transect which crosses the mound feature two times (Fig. 1.20).

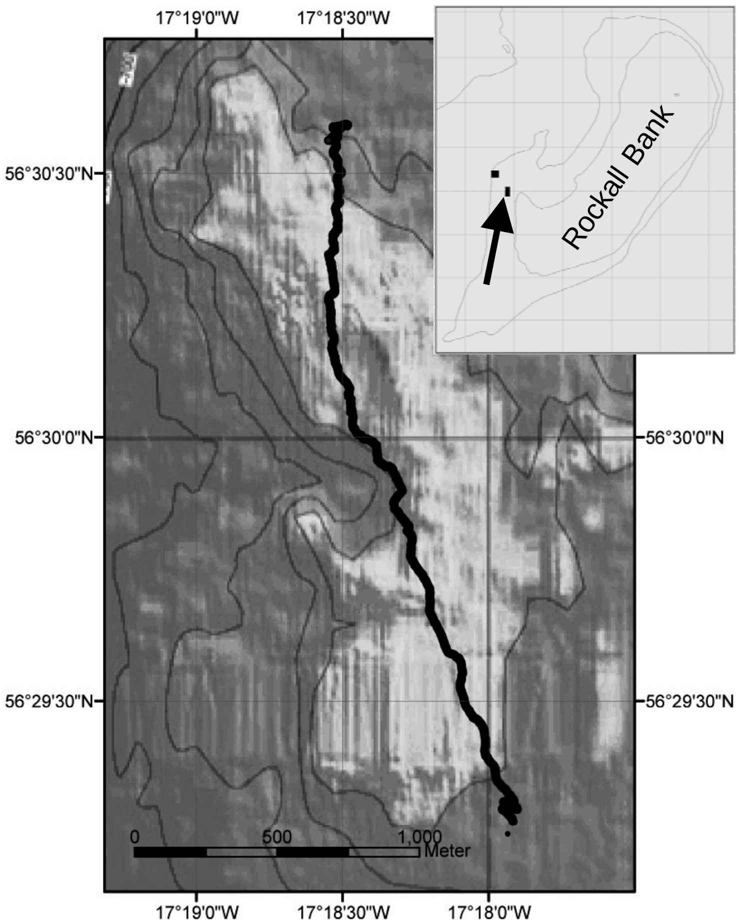



**Fig. 1.19:** Bathymetry of Franken Mound (WRB, for overview see inserted map (arrow)) and the OFOS dive #7 from south to north).

Facies A Muddy sand

Facies A is typically found off-mound in a variety of subfacies in water depths deeper than 660 m. Most distally the muddy sand plains are structured by current-ripple marks. Muddy sand without ripple marks is highly bioturbated. Closer to the mound, pebble-sized dropstones and boulders become more abundant. These boulders are colonised by antipatharians and encrusting holothurians *(Psolus* sp.). Benthic life is rich. There is plenty of cidaroid echinoids, holothurians, decapods *(Paromola cuvieri, Chaecon affinis)* and fish such as *Helicolenus* sp.

Facies B Barren carbonate limestone

The basement of Franken Mound is difficult to evaluate without seabed samples, but the weathering profile and bedding planes visible on some OFOS images point to a limestone origin. If correct, the limestone consists of massive sedimentary units or deci-to-centimetre-thick layers. Some underwashed carbonate crusts occur as well and they show signs of dissolution patterns (probably dissolution of aragonite fossils during diagenesis?). The basement crops out on all steep flanks within the inner mound area and provided hardsubstrate for a diverse epibenthic fauna, including scleractinians, gorgonians, antipatharians and demosponges. Several colonies of the octocoral *Anthomastus* sp. and bushy hydroids have been identified on the crustground.

Facies C Coral thicket/rubble

The coral thickets on Franken Mound are the largest one found during the entire M61-1 cruise. The thickness often exceeds 1 m and is attached to subvertical basement outcrops or plain carbonate crusts. The framework is primarily made by *L. pertusa* and to a lesser degree by *M. oculata*. Rarely, living *Stylaster* sp. and *Aprhrocallistes bocagei* were documented. The dead coral framework often is densely colonised by a yet not identified actinian and by *Phelliactis hertwegii*. Lost fishing gear was found several times entangled within the corals.

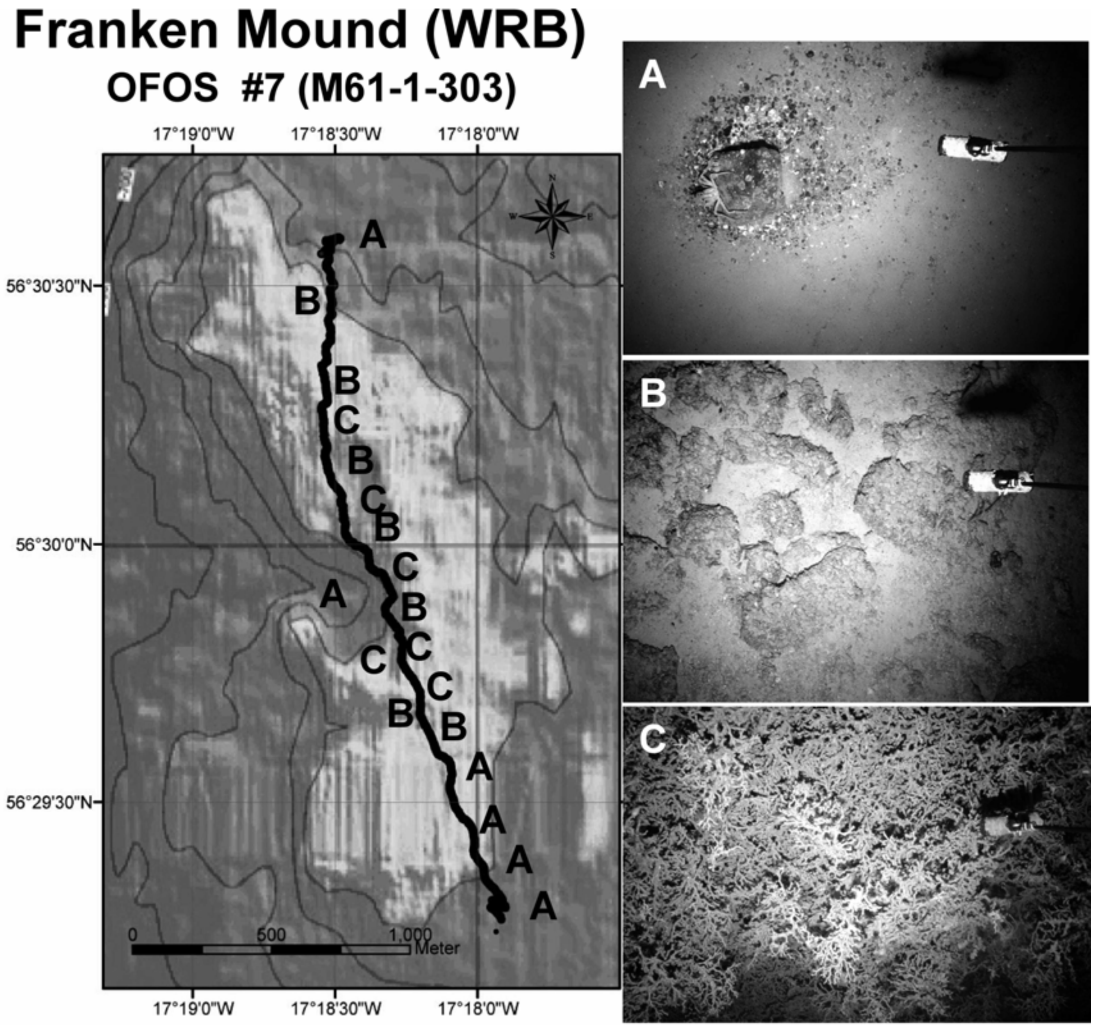



**Fig. 1.20:** Facies interpretation of OFOS-Dive #7 over Franken Mound in the WRP area: A = Muddy sand; B = Barren carbonate limestone; C = Coral thicket/rubble. The ground weight with a length of 20 cm can serve as a scale bar.

To conclude, in the WRB we found the most intense scleractinian coral growth shallower than 700 m depth (Franken Mound) whereas in deeper waters, corals are mostly dead (Kiel Mount). This situation is contrary to coral growth depth patterns found in the BMP. The sponge community found on Kiel Mount is similar to those living in the Logachev Mound Province, south-western Rockall Trough. Signs of fishing activity are much lesser in the WRB area compared to the BMP, which is littered with lost fishing gear. Our relatively short reconnaissance in the WRB opened the door for further exploration of a new coral province in the North Atlantic.

### 1.4.4 Composition and Distribution of Zooplankton Above Coral-Covered Carbonate Mounds at the Belgica Mound Province

(Martin, B, Ruseler, S.)

Deep-water corals are potential predators for zooplankton. This study aims to detect their impact on the fauna in the water column above and near the coral-covered mounds. In this context it is of special interest to analyse the faunal composition of the bottom-near layers as well as the structure and dynamics of the diurnaly migrating zooplankton of the deep scattering layer above the upper slopes and the summits of mounds. Furthermore, if spawning of corals and associated fauna takes place in spring, surface near layers could host eggs and larvae of these organisms.

Pelagic metazoans were collected above the slopes and the summit of Galway Mound.Standard devices for the quantitative collection of zooplankton was a 1 $m^2$- MOCNESS (Wiebe et al.,. 1985) equipped with 9 nets of 0.333 mm mesh size. The net can be opened and closed sequentially and is equipped with an integrated CTD. All data are transmitted to an onboard computer. The water column was traversed by stratified oblique tows and bottom-near horizontal hauls (Tab. 1.1 and 1.2). The filtered volume is calculated by a flowmeter.

To investigate diel vertical migrations of the zooplankton hauls were carried out during day and night. To detect the depths and dynamics of the deep scattering layers the data of a 33kHz echo sounder were recorded during the stations. The fresh material was preserved in 4% formaldehyde in seawater. One haul was frozen at –80°C and will be send to Prof. G.A. Wolff, Earth & Ocean Sciences Department Liverpool, for biochemical analysis

**Tab. 1.1:** MOCNESS –haul data (a.b. = above bottom, w.c. = water column)

| station # | date | time | position begin Lat. °N | long. °W | position end latitude °N | long. °W | water depth m | haul # | catch depth m | remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 234 | 22.04.04 | day | 51°29.88 | 11°42.05 | 51°22.71 | 11°48.94 | 845-1016 | 1 | 1-80 m a.b. | a.b. |
| 236 | 22.04.04 | night | 51°29.67 | 11°45.58 | 51°22.65 | 11°45.58 | 870-986 | 2 | 10-120 m a.b. | a.b. |
| 237 | 23.04.04 | night | 51°30.35 | 11°45.05 | 51°25.14 | 11°45.42 | 890-982 | 3 | 800-0 | 2 nets a.b., rest w.c. |
| 244 | 23.04.04 | day | 51°29.47 | 11°45.06 | 51°24.93 | 11°45.38 | 942-973 | 4 | 350-0 | w.c. |
| 245 | 24.04.04 | night | 51°24.93 | 11°45.08 | 51°30.99 | 11°45.05 | 790-971 | 5 | 840-0 | 2 nets a.b., rest w.c. |
| 245 | 24.04.04 | night | 51°25.18 | 11°45.08 | 51°31.14 | 11°45.05 | 800-970 | 6 | 850-0 | 2 nets a.b., rest w.c. |
| 245 | 25.04.04 | day | 51°25.05 | 11°45.03 | 51°30.08 | 11°45.15 | 790-970 | 7 | 750-0 | 2 nets a.b., rest w.c. |
| 245 | 25.04.04 | day | 51°25.23 | 11°45.09 | 51°30.96 | 11°45.13 | 807-971 | 8 | 750-0 | 2 nets a.b., rest w.c. |

First qualitative studies showed relatively high abundances of fish- and evertebrate larvae in all samples, one of the latter occured in masses. Wether these are larvae of corals has to be further analysed. Several specimens of Pipefishes (Family Syngnathidae) were caught in the upper 50m

during Haul 2, 3, 7. In the bottom-near layers (net 2 and 3 of haul 2, 6, 7, 8) fish-larvae, decapods as well as medusae were found in greater numbers. In addition adult polychaets were caught at 120 m above bottom at haul 2. At the first tow two of the nets touched the bottom and were filled with corals including associated fauna.
At the south-north tracks the gear reached the bottom-near layers in 800m by paying out about 1100 meters of wire whereas during the north-south tracks up to 2000 meters of wire were needed to reach the same depth which was probably caused by a strong current to the north.

**Tab. 1.2:** MOCNESS hauls: sampled depth intervals. mab = meters above bottom.

| MOC-1-01 | | MOC-1-02 | | MOC-1-03 | | MOC-4-01 | | MOC-1-05 | | MOC-1-06 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Net | catch depth | Net | catch depth | Net | catch depth | Net | catch depth | Net | catch depth | Net | catch depth |
| 01 | 0m-30mab | 01 | 0m-110mab | 01 | 0m-130mab | 01 | 0m-350m | 01 | 0m-80mab | 01 | 0m-160mab |
| 02 | 30-80mab | 02 | 50mab | 02 | 800-700m | 02 | 350m | 02 | 90mab | 02 | 90-160mab |
| 03 | 80-20mab | 03 | 50mab | 03 | 700-600m | 03 | 350-300m | 03 | 80mab | 03 | 70-90mab |
| 04 | 1-40mab | 04 | 70mab | 04 | 600-500m | 04 | 300-200m | 04 | 800-600m | 04 | 740m-600m |
| 05 | 40-80mab | 05 | 30-70mab | 05 | 4500-400m | 05 | 200-150m | 05 | 600-500m | 05 | 600-500m |
| 06 | 40mab-0m | 06 | 80-120mab | 06 | 400-300m | 06 | 150-100m | 06 | 500-400m | 06 | 500-300m |
| 07 | - | 07 | 120mab | 07 | 300-100m | 07 | 100-75m | 07 | 400-0m | 07 | 300-0m |
| 08 | - | 08 | 120-140mab | 08 | 100-50m | 08 | 75-50m | 08 | - | 08 | - |
| 09 | - | 09 | 140mab-0m | 09 | 50-5m | 09 | 50-0m | 09 | - | 09 | - |

| MOC-1-07 | | MOC-1-08 | | MOC-1-09 | |
|---|---|---|---|---|---|
| Net | catch depth | Net | catch depth | Net | catch depth |
| 01 | 0m-740m | 01 | 0m-30mab | 01 | 0m-720m |
| 02 | 730m | 02 | 30-80mab | 02 | 720-770m |
| 03 | 750m | 03 | 80-20mab | 03 | 50mab |
| 04 | 40mab | 04 | 12-40mab | 04 | 720-600m |
| 05 | 730-600m | 05 | 40-80mab | 05 | 600-500m |
| 06 | 600-500m | 06 | 40mab | 06 | 500-300m |
| 07 | 500-300m | 07 | 73mab | 07 | 300-100 |
| 08 | 300-100m | 08 | 70-10mab | 08 | 100-50m |
| 09 | 100-0m | 09 | 10mab-0m | 09 | 50-0m |

### 1.4.5 Deep-Sea Observation System (DOS)

(Linke, P., Pfannkuche, O., Schönfeld, J., Bannert, B., Türk, M., Queisser, W.)

Particle flux and bottom water currents with changes in velocity and direction as well as fluctuations in hydrostatic pressure, due to tidal or meteorological influences are expected to have an impact on the exchange processes and biological interactions at the sediment/water inface in coral thickets. To monitor these oceanographic control parameters in combination with megabenthic biological activity the Deep-sea Observation system (DOS) was deployed on Galway Mound (BMP) (Figs. 1.21 and 1.22).

The long-term observatory was equipped with a wide range of sensors, sampling and experimental gear (Tab. 1.3). This included a storage CTD, three acoustic current meters, a sediment trap and a stereo camera system. SAMS/Oban deployed a number of optical sensors (transmissiometer, fluorometer, optical backscatter) in 50 cm distance from the seafloor. A 300 kHz ADCP heading upwards into the water column measured every 15 min the current regime in 3-m cells within a range of 7.6 to 110 m above bottom. Simultaneously, a downlooking 1200 kHz measured currents in 10-cm cells within the first 100 cm of the sediment-water interface. Another acoustic current meter equipped with a turbidity meter is mounted next to the sediment trap which samples in 8-day intervalls the particle deposition.

Furthermore, the foot plates of the lander were equipped with tableaus containing various substrates for larvae colonisation. These compose of: 1 round colonisation chamber filled with sand covered by a sieve (1.5mm), 2 rectangular colonisation chambers filled with sand, 2 tableaus with pebbles with various lithologies, and 2 bars with coral pieces. The rectangular chambers are closed during descend and ascend of the lander. The lids are openend by spring action triggered by burn wire and closed by the ballast release of the lander.

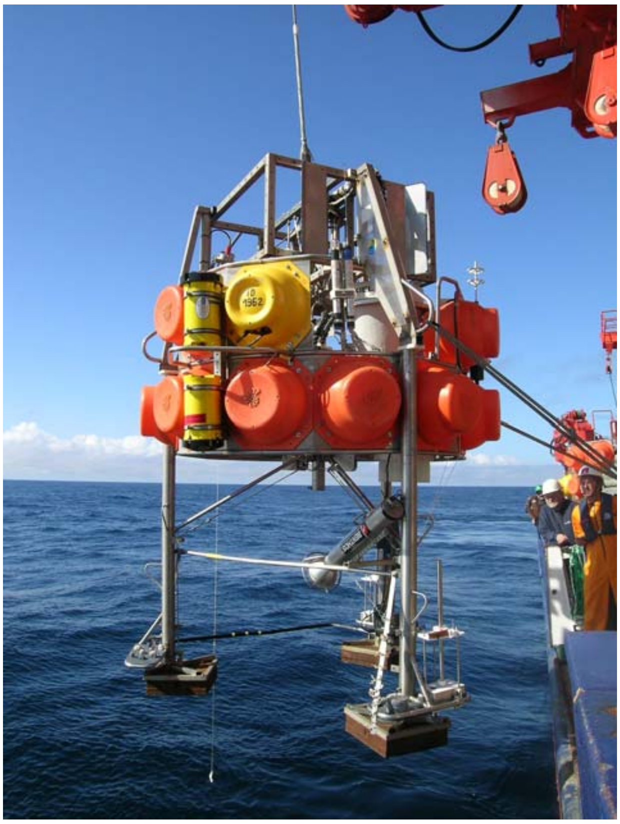


**Fig 1.21:** Deployment of the DOS-Lander

**Fig. 1.22:** The DOS Landers settled in a coral thicket on top of Galway Mound

The long-term observatory (GEOMAR modular lander, Pfannkuche and Linke 2003) was deployed video-controlled under ideal weather conditions on April 25th on top of a coral thicket of Galway Mound and will be recovered mid August with R/V POSEIDON. The time of this deployment will allow the assessment of strong seasonal fluctuations in the particle flux from the spring bloom to the summer situation. The stereo images taken in 3-hour intervals will be used for the analysis of structural changes on the reef as well as for the description of occurrence and activity of vagile megafauna. The benthic colonisation experiments will provide information about of the colonisation and modification of various substrates attached to the lander.

*SAMS Optical Instruments integrated into the DOS Lander*

It is thought that as suspension feeders, *Lophelia pertusa* and other cold water corals may be sensitive to increased levels of sedimentation in reef environments which may result from naturally or anthropogenic derived disturbance events. However, little is known about the natural levels of suspended particulate matter around cold water coral reefs or the upper concentrations of suspended matter in which a cold water coral can survive. Indeed visual surveys of deep-water reef environments show ripple-marked sands indicative of active near-bed sediment transport and the reef structures themselves are built upon coral frameworks infilled by mobile sediments. By deploying our optical instruments on a cold water coral reef we will obtain a baseline of natural levels and optical properties of suspended particles in such an environment. These data can be used to derive estimates of near-bed resuspension and in the future may be compared with concentrations of suspended particulate matter in disturbed cold water coral reef environments.

**Tab. 1.3:** Equipment and settings of the DOS Lander

| **Equipment** | **Stereo-Camera** | **Trap** | **ADCP** | **ADCP** | **MAVS-3** | **CTD** |
|---|---|---|---|---|---|---|
| **Model S/N** | Benthos 055(B)+056(A) | KUM | RDI 0779 | RDI 1015 | Nobska 10107 | SBE16plus 1484 |
| **Specs** | 30m film with 850 frames | 13 sample cups | 300KHz | 1200 kHz | C/T/D/Turbidity | C/T/Digiquartz |
| **Settings** | 200ASA / f = 11 / 0.8-1.8 | 8 day interval | 84MB / 42V | 74MB / 42V | 64MB / 14.13V | 8MB / 13.5V |
| | 183min interval | | 15min ensemble interval | | 15min burst interval | 10min interval |
| **Position** | downlooking | uplooking | uplooking | downlooking | uplooking | downlooking |
| **height** | 164 cm | 275 cm | 258 cm | 164 cm | 286 cm | 164 cm |
| **Alignment** | | | groove towards DOS-Lander | | hole away from DOS | |

| **Equipment** | **Optical package (SAMS)** | | | |
|---|---|---|---|---|
| **Model S/N** | UMI-datalogger 2145 | C-star transmiss. 561DR | WETLABS LSS 341 | Fluorometer AFLT-030 |
| **Specs** | | turbidity | | chlorophyll |
| **Settings** | 512kb / 12V | | | |
| | triggers sensors for a 60sec burst every 60min with 15sec delay | | | |
| **Position** | horizontal | horizontal | horizontal | horizontal |
| **Height** | | 50 cm | 50 cm | 50 cm |
| **Alignment** | | parallel to crossbar | away from DOS | away from DOS |

A transmissometer, light-scattering sensor and fluorometer were attached to the GEOMAR DOS Lander so as to lie 50 cm above the seabed in amongst cold water corals on the Galway Mound. The instruments were set to record readings every hour for one minute for up to four months. The results will provide estimates of particle suspension and the optical properties of the particles within this cold water coral reef environment. More specifically, data recorded from the transmissometer will provide an indication of the concentration of matter as well as the seawater clarity, whilst the light-scattering sensor and the fluorometer will monitor the turbidity and chlorophyll concentrations respectively. This work will compliment the first lander deployment on the Galway carbonate mound where the SAMS photolander provided a month-long record from these optical sensors alongside time-lapse photographs, current speed, current direction, temperature and salinity (Roberts et al. in press). This photolander was deployed at 51º 27.09N 11º 45.24W (824 m water depth). The GEOMAR DOS lander was deployed at 51º 27.28N and 11º 45.23W (806 m water depth). The lander will be recovered in August from R/V POSEIDON.

### 1.4.6 Benthic Bioluminescence in the Vicinity of Deep-Water Coral Habitats

(King, N., Heger, A., Jamieson, A., Wigham, B.)

In the marine environment, a large number of organisms have the capacity to emit visible light or bioluminescence. The Oceanlab ISIT (Intensified Silicon Intensifying Target/Tube) camera is designed to record deep-sea bioluminescence. Previous studies in the NE-Atlantic have successfully employed the ISIT camera to record benthic bioluminescence from a baited lander.

For this cruise, the ISIT camera was incorporated into a GEOMAR modular lander and positioned in front of a baited benthic chamber unit. In addition a Sensortek current meter was mounted on the lander frame to record current velocities, direction and also temperature, pressure and salinity. The lander was positioned on the seabed using the Oktopus video launcher system.

The main aim of this series of deployments was to study benthic bioluminescence in relation to deep-water corals and to determine whether the frequency and intensity of occurrence of spontaneous (non-stimulated) bioluminescence would change with increasing distance from the coral mounds. It was hypothesised that the frequency and intensity of bioluminescent emissions would increase in the vicinity of corals, as they are known biodiversity hotspots.

In addition, the collection of potentially bioluminescent organisms, using the adapted baited benthic chamber, allowed for the assessment of stimulated bioluminescence under lab conditions using a second SIT camera and for the identification of responsible taxa.

During the cruise, 3 deployments were attempted of which only 2 were successful in terms of collecting footage:

*Deployment 1* The first ISIT-BCL deployment was undertaken on the Galway Mound (Porcupine Seabight) amongst a coral community (Stn. #221, depth ~860 m). The ISIT footage showed no consistent amount of bioluminescence. There was no evidence that bioluminescence is related to any feeding activity but emission of light was observed during the closing of the chamber, probably as a result of mechanical stimulation. As a result of the dense aggregations of corals the chamber was unable to successfully recover any sediment from the seafloor. Accompanying data from this area indicated that the dominant scavengers were lysianassid amphipods and the eel *Synaphobranchus kaupi*.

*Deployment 2* The second deployment was located at the base of the Galway Mound (Stn. #235, depth ~926 m) in an area of softer sandy sediments away from any obvious coral patches. Unfortunately, this deployment was unsuccessful as the camera failed to run and the chamber was unable to collect any significant amount of sediment.

*Deployment 3* The third ISIT-BCL deployment was located on an area of soft sediment at the base of Kiel Mount on the Rockall Bank (Stn. #285, depth ~950 m). During this deployment a large number of eels (*S. kaupi*) were observed and the video footage showed a significant number of large bioluminescent events.

Amphipod traps, attached to the ROBIO lander deployed in the same area, recovered lysianassid amphipods and ostracods. Lab investigations showed that the ostracods were responsible for bioluminescence. They ejected a viscous substance that emitted a pale blue light, visible to the naked eye, when mechanical (shaking) and chemical (potassium chloride solution) stimulation were applied.

In addition, amphipod and ostracod tissue samples were taken and preserved in RNA later for subsequent analysis of gene expression and eyes were frozen for visual pigment analysis.

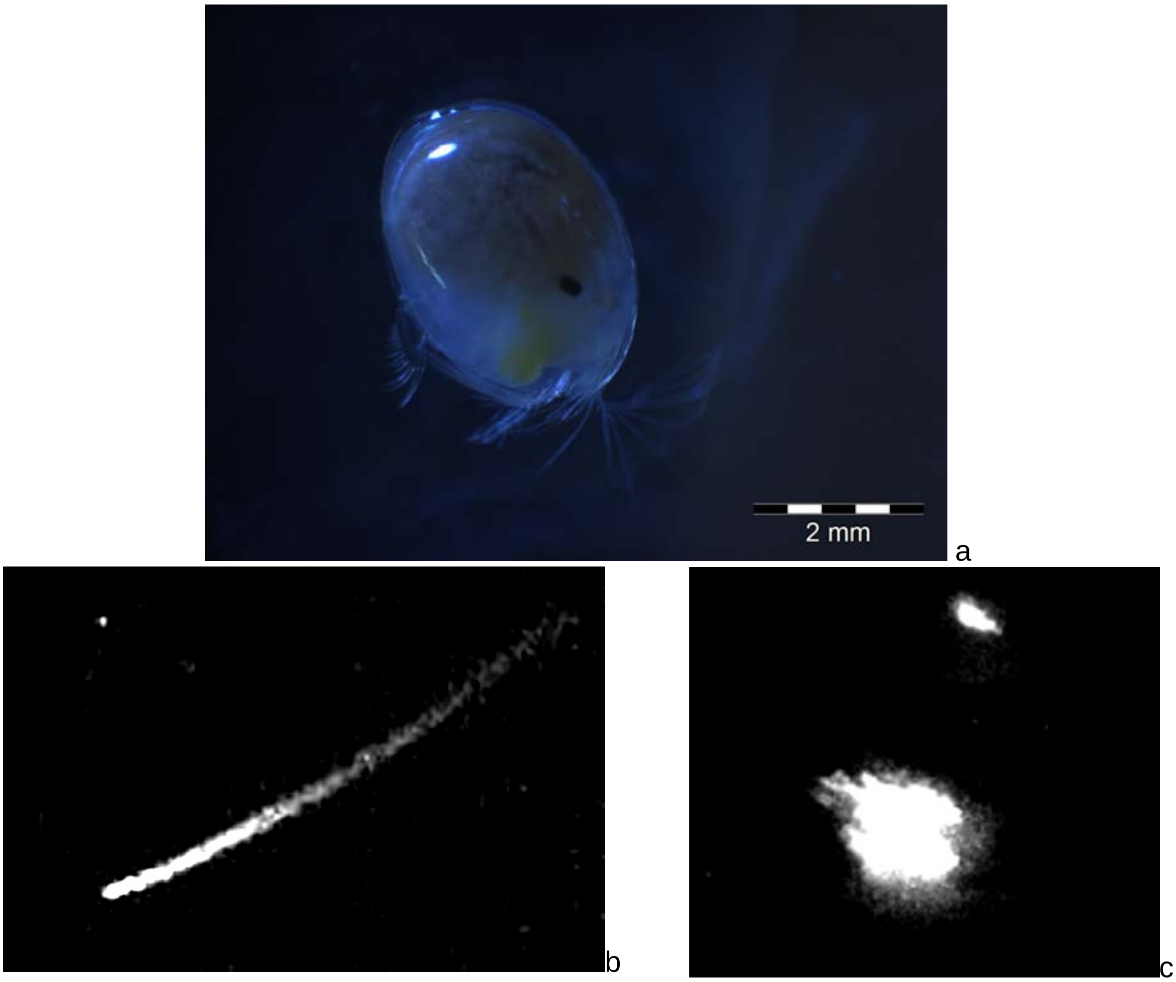



**Fig. 1.23:** Ostracod bioluminescence, a) Microscope image of luminescing ostracod, b) still image from ISIT video of single luminescent event on the seafloor during deployment 3, c) still image from ISIT video of large luminescent event on the seafloor during deployment 3.

### 1.4.7 Assessment of Scavenging Ichthyofauna Using a Baited Camera Lander

(King, N., Heger, A., Jamieson, A., Wigham, B.)

The primary aim of this experiment was to compare the distribution of scavenging ichthyofauna and invertebrates both on and off carbonate mound/coral outcropping areas in the Porcupine Seabight, and on soft sediment on the Rockall bank. The secondary aim was to obtain representative images of deep-sea fish assemblages for public outreach and education purposes.

Still photographs were captured using the baited RObust BIOdiversity lander (ROBIO) equipped with a Kongsberg digital camera and flash unit (Fig. 1.24). The lander was baited with 4 mackerel positioned 950mm in front of the camera lens on a titanium arm. The lander was deployed in “landing mode” (ROBIO may also be “tethered” above the seabed or “flown” over the seabed on a wire connected to the ship) using a 3-pointed squat clump ballast.

The baited ROBIO lander was deployed at three separate stations, 2 in the Porcupine Seabight (PSB) and 1 on the Rockall Bank.

*Deployment 1* The ROBIO was first deployed south of the Belgica Mound Province (Stn. # 202, depth 931m) at a location previously identified as a bioluminescent hotspot (E. Battle pers comm.). This location was in an area of soft sediment close to buried carbonate mounds (De Mol et al., 2002). Digital still images were captured every minute for a total of 6 hrs 24 min post-touchdown. The images revealed the dominant scavengers to be the eel *Synaphobranchus kaupi* and lysianassid amphipods. Other fishes attracted to the bait were several species of elasmobranch (Fig. 1.23a.) and the teleost fishes, *Mora moro* and *Phycis blennoides*. Baited traps attached on the underside of the lander recovered a number of lysianassid amphipods and potentially other small invertebrates. Bioluminescence was observed within the traps using a Silicon Intensifying Target (SIT) low-light camera. However, the organisms responsible were not identified.

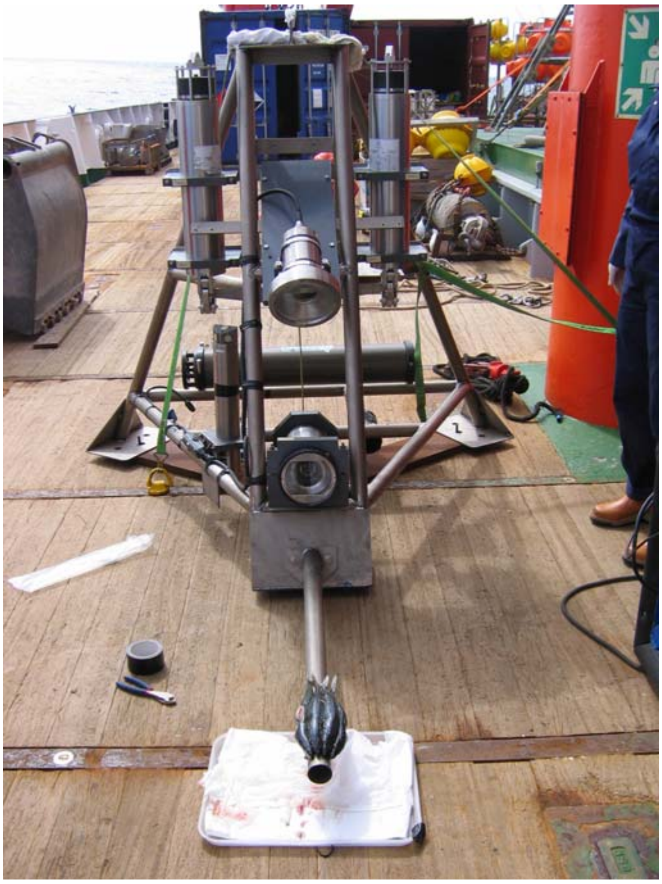


**Fig. 1.24:** The RObust BIOdiversity lander (ROBIO) showing baited arm, camera, flash and twin acoustic releases.

<u>Deployment 2</u> The second ROBIO deployment was located on the periphery of the Pollux Mound (Stn. # 246, depth 981m). Digital still images were captured every minute for a period of 5 hours 56 minutes. during the night and early morning of the 25$^{th}$-26$^{th}$ April. The lander settled at a 10° tilt, possibly a result of resting on a raised area of coral outcropping. *Madrepora* sp., *Acapnella* sp. and unidentified sponge species are clearly visible on the benthos (Lydia Beuck, personal comm.). The dominant scavengers were the teleost fishes, *Mora moro* (Fig. 1.25a.) and lysianassid amphipods. There was a clear reduction in the number of *Synaphobranchus kaupi* attracted to the bait compared to deployments 1 and 3. Elasmobranch species attracted to the bait included *Galeus* sp. and an unidentified Scyliorhinid. Benthic invertebrate fauna observed were the crustaceans *Bathynectes* sp. and *Munida tenuimana*. Bioluminescence was not recorded from the amphipods recovered in the traps.

*Deployment 3* The third ROBIO deployment was on the Rockall Bank in an area of soft sediment at the base of the Kiel Mount (Stn. #286, depth 934 m). The amount of bait placed on the titanium arm was increased to 8 mackerel and one additional bait fish was secured inside the pole to prevent early removal of the bait by large scavengers. The dominant scavengers attracted to the bait were the eel *Synaphobranchus kaupi*, lysianassid amphipods and several species of elasmobranch, including *Centrophorus* sp. (Fig. 1.25b) and *Deania calceus* (Fig. 1.25c.). Teleost fishes *Mora moro* and *Phycis blennoides* were also present at the bait. Invertebrate fauna observed in the area surrounding the bait were a gastropod mollusc, *Colus* sp., pagurid crabs, a spider crab and numerous ophiuroids. Numerous ostracods appeared to swarm around the bait and be consumed by *Synaphobranchus kaupi*. Both amphipods and ostracods were recovered in baited traps positioned on the underside of the lander.

a

b

c

**Fig. 1.25:** a) *Mora moro.* b) *Galeus* sp. c) *Synaphobranchus kaupi* and *Deania calceus*. For scale see the full lander in Fig. 1.24.

### 1.4.8 Sediment Sampling and Foraminiferal Studies

(Schönfeld, J.)

Among small benthic organisms, foraminifera are found in all marine environments, depict high species richness, and their tests are well preserved in the fossil record. It is commonly recognized that deep-sea benthic foraminiferal faunas are strongly structured and reflect changing environmental conditions. Over the last three decades, a basic concept has been developed how environmental factors, in particular food and oxygen, influence benthic foraminiferal assemblages (Altenbach and Sarnthein, 1989; Jorissen et al., 1995; Fariduddin and Loubere, 1997; Van der Zwaan et al., 1999; Fontanier et al., 2002). A suite of key species was assessed that serve as reliable indicators for the origin, amount, and quality of particulate organic matter reaching the sea floor (Gooday, 1988; Gooday and Lambshead, 1989; Caralp, 1989; Altenbach et al., 1999) and a serious drawdown in bottom-near water oxygenation (Kaiho, 1994; Baas et al., 1998; Cannariatto and Kennett, 1999; Bernhard and Sen Gupta, 1999; Schönfeld, 2001). These valuable taxa for palaeoceanographic and palaeoecological interpretations represent, however, only a few percent of all species present. From concomitant variations in species-independent assemblage parameters as abundance, diversity, and dominance it is evident, that the entire fauna responds to changing environmental conditions (Murray, 2001; Gooday, 2003). Biotic processes such as competition, predation, facilitation, disturbance, recruitment, and interaction with large metazoans and bacteria leave also an impact in the structure of foraminiferal communities (Haward and Haynes, 1967; Dobson and Haynes, 1973; Alexander and DeLaca, 1987; Freiwald und Schönfeld, 1996; Beaulieu, 2001; Ernst et al., 2002; Langezaal, 2003). This web of direct and indirect effects and its expression in assemblage parameters and foraminiferal distribution patterns is yet partly known and poorly understood.

The distribution pattern of benthic foraminifera from the Porcupine and Rockall areas to the south and west off Ireland is only partly known, and it has not been systematically compiled to date. Near-shore studies concentrated on western Irish bays, Bristol and St. Georges Channel and provided only regionally confined information (Heron-Allen and Earland, 1913; Murray, 1970; Dobson and Haynes, 1973; Lees et al., 1969). A definition of benthic foraminiferal associations, survey of their distribution, and assessment of primary controlling environmental factors was presented by Weston (1985) for the Porcupine Seabight and Western Approaches continental slope. The carbonate mound province on the eastern slope of the Porcupine Seabight was left out, probably because the grab samples contained a high amount of sand-sized detrital material (Weston, 1982). A first description of benthic foraminiferal faunas from carbonate mounds is based only on four gravity cores from the Porcupine Seabight (Coles et al., 1996). The foraminiferal abundance was lower but the diversity was higher on the mounds as compared to the ambient sediments suggesting that the hard substrates provide more niches for a wider variety of foraminiferal taxa.

The foraminiferal studies intend to improve the sample coverage on the western Irish margin in order to facilitate a systematic survey of benthic foraminiferal species distribution and assemblage parameters. The regional scope is combined with detailed investigations of micro and meso-scale patchyness for a determination of microhabitat structures and biofacies patterns. Together with a joint biodiversity assessment including macrofaunal groups, the data will reveal biotic interactions and limiting environmental factors. This will help to localise key areas of high environmental sensitivity for foraminiferal assemblages and to describe the interaction with ambient biocoenoses. Emphasis is likewise given to abiotic factors. We will assess the influence of different trophic regimes, near-bottom currents and substrate properties on sensitive key areas.

Sedimentary archives are studied in order to constrain periods of elevated environmental stress during the Holocene and last Glacial and to describe the response of foraminiferal diversity and assemblage structure. These studies are accompanied by colonisation experiments. They may help to develop an understanding how fast a living assemblage will react to profound environmental changes in a way that the signal is transferred to the fossil record.

Paleoceanographic objectives for sediment coring were to obtain records of carbonate mound development, intermediate water circulation, sediment accumulation during of Late Pleistocene climatic fluctuations. Especially we intend to trace the Glacial North Atlantic Intermediate Water formation that has been suggested to have taken place in this region (Saidov and Haupt, 1997).

Surface sediment sampling

A box corer was deployed at 15 stations in the Belgica Mound province and at Kiel Mount, Rockall Plateau without technical problems (Fig. 1.26 and 1.27). The box corer used permits the recovery of 50 x 50 x 50 cm of surface sediments. When on board, the overlying water was sucked off and passed through a 0.3 mm mesh to collect small, vagile benthic organisms. The surface sediment or coral rubble was then sampled as described below.

A Van Veen Grab sampler was used at 29 stations in the Belgica Mound province, at Kiel and Franken Mound, Rockall Plateau. Even though the device was deployed regularily with a pinger in order to recognize bottom contact, it often failed and brought no substantial recovery. Representative samples were only retrieved from dense coral thickets or homogenous sands. The sediment surfaces from sandy bottom were occasionally well preserved. When on board, the lids were opened for a first assesment of sample quality and decision for subsequent procedures. Once the surface sediment was well preserved, sampling was performed through the lids. In case the grab contained coral rubble, a few dropstones or shell debris, it was opened over a plywood tray, documented and sampled for macrofauna. The inventory of living makroinvertebrates is given in the chapter on macrofaunal analyses.

Sampling procedure for foraminiferal studies

The foraminiferal studies require largely undisturbed sediment surfaces and a representative coverage of different microhabitats and small-scale variations in sediment composition. Thus we mainly focused on box core samples. Van Veen and TV grab samples were also considered in case a first visual inspection suggests that material from the immediate surface was recovered (Fig. 1.26 and 1.27).

The uppermost centimetre was sampled on box core surfaces. We used a frame of 87,6 $cm^2$ that was pushed in the sediment at two different places. A representative coverage of different microenvironments on the sediment surface was attempted. The sediment was carefully removed with a spoon. A 1 cm - gauge on the inner side of the frame helped to keep the required depth level. The final sample volume was marked on the vial, and the surface sample was immediately conserved and stained with a solution of 2 grams Rose Bengal in 1 litre Ethanol (technical quality, 98%) (Lutze and Altenbach, 1991; Murray and Bowser, 2000). This sample will be used to study the living, shallow epi- and endobenthic foraminifers, and the dead assemblage in the surface sediment.

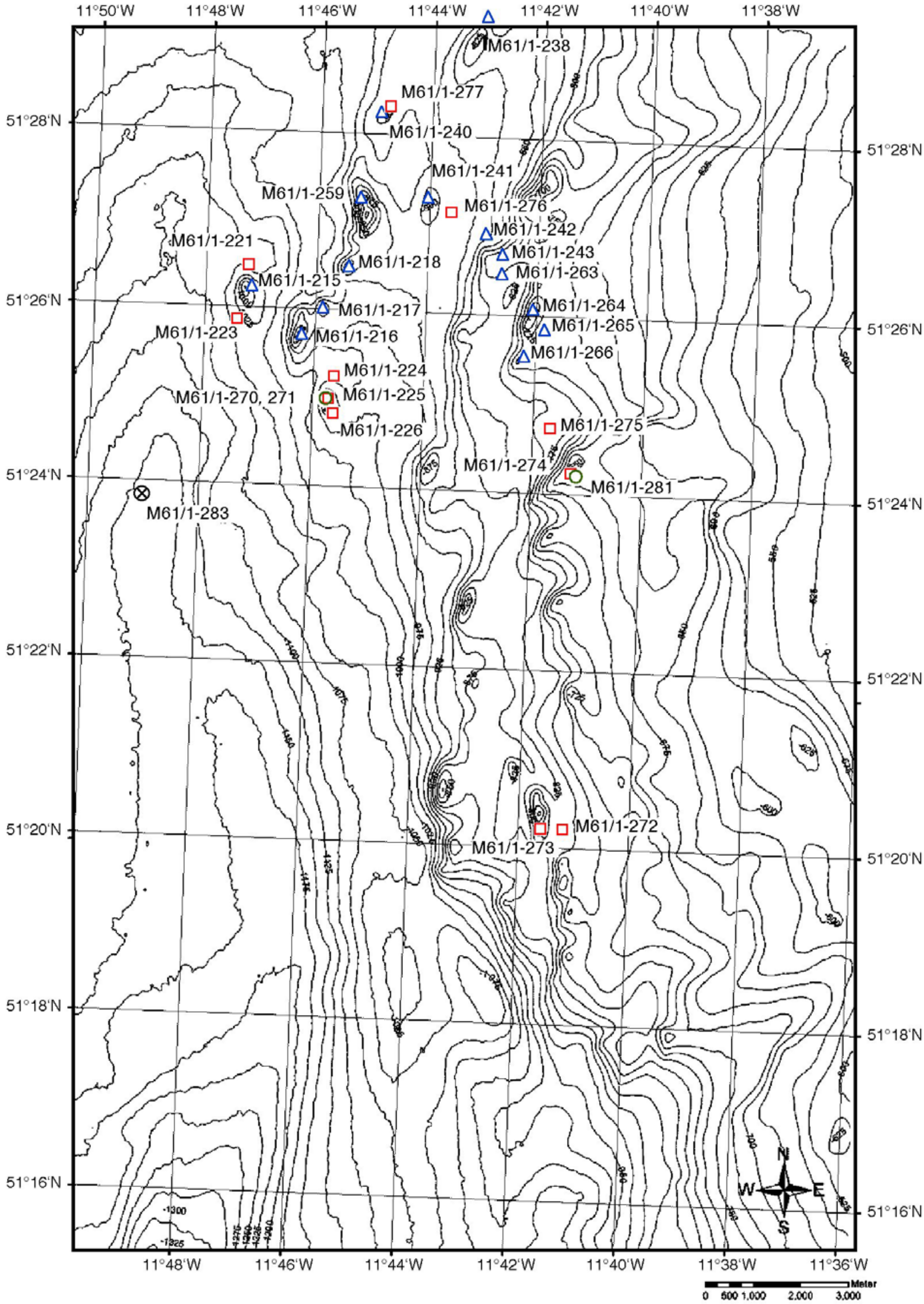



**Fig. 1.26:** Map of foraminiferal samples from the Belgica Mound area, Porcupine Trough. Squares: box cores, triangles: grab samples, circles: sediment cores, crossed circle: multicorer. Note that the colonization experiment is deployed at the location of sample M61-1-259 on top Galway Mound.

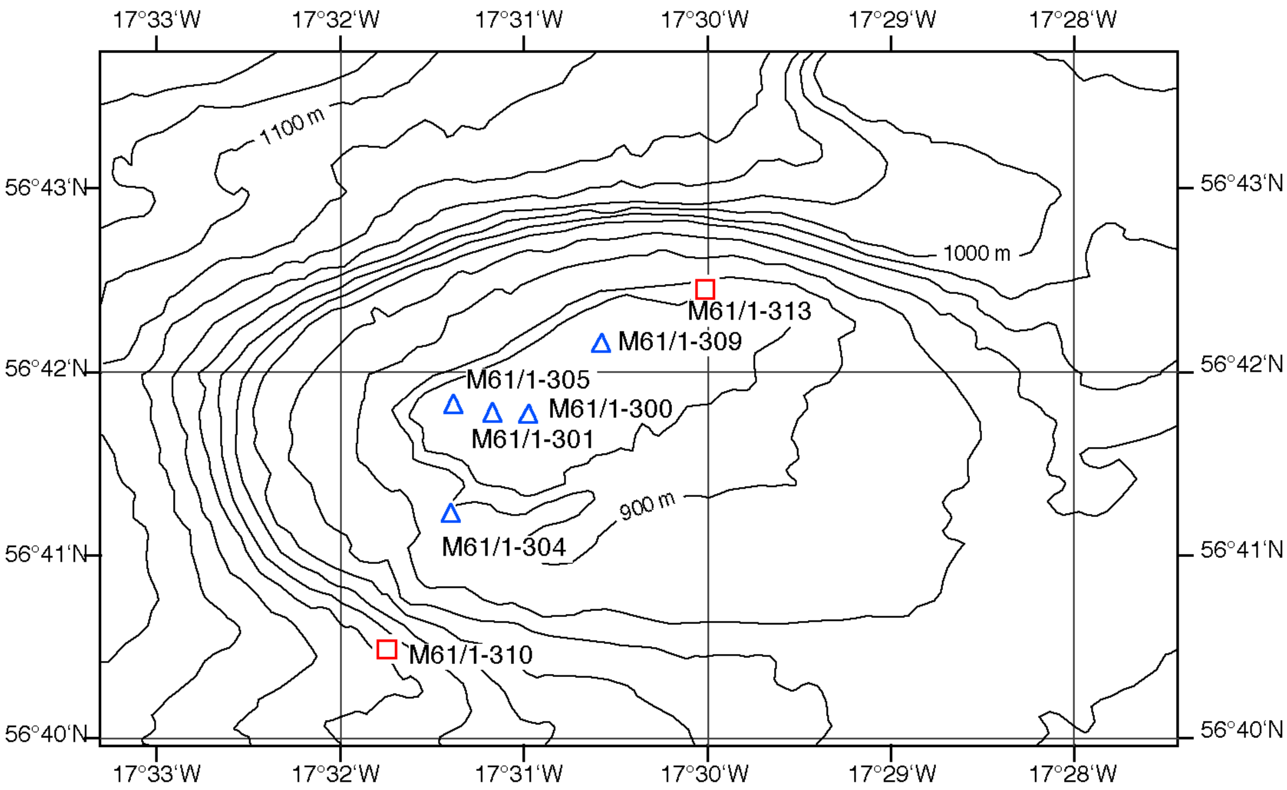



**Fig. 1.27:** Map of foraminiferal samples from Kiel Mount area, Rockall Bank. Squares: box cores, triangles: grab samples.

A representative suite of elevated hard-substrates like dropstones, coral debris or mollusc shells were carefully removed from the sediment surface of box cores and conserved in Rose Bengal - Ethanol too. These objects will be examined for attached epibenthic foraminifers (Oschmann, 1990; Schönfeld, 1997; 2002). Staining facilitates the recognition of living specimens, as it has been proven that empty tests of *Placopsilina confusa* and *Cibicides refulgens* still stick to the host after reproduction. Particular attention was paid for a careful handling of these objects to not destroy the "mudline" of fine, adherent sediment that serves as zero level for the attachment height of epizoans.

After surface sampling and removal of elevated objects, a 10 $cm^3$ syringe sample was taken from the surface close to the frame. This sample will be used to analyse the organic carbon and chlorine content of the surface sediment. The lid of the box corer was opened and an archive box covering the near-surface strata was taken as reference. Furthermore, a 2 cm - spaced series of 10 $cm^3$ syringe samples was taken for studies of Holocene foraminiferal and palaeoceanographic records.

A different sampling scheme was followed once the box corer or grab recovered coral rubble. As the original texture or framework was mostly disarranged due to sampling, a zero level could not be defined. Therefore, a representative variety of hard-substrates were removed from different places of the sample and conserved in Rose Bengal - Ethanol. Preference was given to pieces that show overgrowth by foraminifera (mostly large specimens of *Cibicides lobatulus* or *C. refulgens* visible by eye), hydroids, crinoids or sponges. Interstitial sediment was sometimes present around coral fragments in the lower part of the box core or grab samples. The soft, upper levels of this sediment were scraped off with a spoon as separate sample that was conserved in Rose Bengal - Ethanol too.

Sediment coring

We used a conventional gravity corer with tube lengths of 3 and 6 m and a weight of 1.5 tons. Three gravity cores with a total length of 1194 cm were recovered from five stations. A 277 cm and a 405 cm and long core of hemipelagic foraminiferal mud with abundant coral fragments were retrieved from the top of Pollux Mound (Stat. 271). Another core from the vicinity of a buried mound retrieved 512 cm of dark grey hemipelagic mud (Stat. 281) (Fig. 1.26). Gravity coring was not successful in lag deposits near mounds Galway, Therese and Pollux (Stat. 282), and in foraminiferal sands overlying brown muds to the south of Kiel Mount (Stat. 312).

The cores were cut into one-metre sections and stored under cool conditions. Opening, description and sampling on board was dismissed, as logging and X-Ray tomography will be done before opening. The computer tomography images will provide further insight into the abundance and orientation of coral fragments in the sediment succession.

Colonisation experiments

Benthic colonisation experiments were deployed with the DOS lander.The colonisation experiment comprised a variety of natural hard and soft substrates mounted to the footplates of the lander. We chose dropstone-alike beach pebbles of limestones, basalts, and granite as hard substrates and exposed them horizontally close to the seabed. Living and dead coral fragments and limestone pebbles were mounted on vertical poles from 5 to 60 cm above the base of the footplates. Coral fragments were sterilised, and all hard substrates were stripped for epizoans before deployment. Soft substrates include carbonate sand, silty terrigenous sand, and mud. The sediments were also sterilised before deployment, and they were exposed in chambers mounted to the lander footplates.

The substrates simulate various niches of the coral mound environment. Benthic foraminiferal reproduction is considered to take place shortly after spring bloom (Bertram and Cowan, 1999; Gooday and Lambshead, 1989; Gooday and Huges, 2002). The recruitment of elevated substrates is most likely effected by propagules displaced by bottom-near currents (Mullineaux and Butman, 1990; Beaulieu, 2001; Schönfeld, 2002). The temporal and environmental setting thus provides favourable conditions for a recruitment of the exposed substrates.

### 1.4.9 Macrofauna Documentation: The Hidden Biodiversity of Cold-Water Coral Ecosystems

(Beck, T., Freiwald, A., Taviani, M., Vertino, A., Schiemer, I.)

The species diversity of the cold-water coral ecosystem is still poorly explored. This is especially true for the macrofauna that is generally not visible on underwater photographs or video documentation taken from ROVs, OFOS or manned submersibles. During M61-1 great effort was invested to document the fauna alive collected the various sampling gears immediately after sampling. Many species presented here, are illustrated alive for the first time.

Directly after the photographic documentation of the freshly taken seabed samples, all apparent living animals were removed and were placed into seawater-filled basins that were stored in the cold room. After the geological/sedimentological sub-sampling the remaining surface sediment was sieved carefully using mesh sizes from 0.2 to 4 mm. Of main importance was the good preservation of fragile animals. Next step in processing was detailed sorting of living animals under the microscope.

A photographic documentation system was then used to take digital images of the living animals. This time consuming work, however is of utmost importance as many taxa loose important diagnostic features once they are dead and fixed. The IPAL doc umentation system consists of a computer-guided digital camera system mounted on a binocular. The ANALYSIS software package provided a multitude of different photographic features.

Specimens larger than 3 cm were documented using an ordinary digital camera. As a last step the remaining sieve fraction was either fixed with 70% Ethanol or simply air-dried. Taxonomic groups not covered by the expertise on board were documented, using the photographic documentation system provided by the IPAL group. The documented specimens were kept separately and will be sent to specialists for further reliable identification.

In situ documentation is of major interest concerning all kind of epifauna. In the present context especially the in situ documentation of epifauna on coral framework allows to get more information about the species associations of that specific substrate. Due to the fact that the studied coral habitats are not easily accessible, the knowledge about the habitat and the animals living there is still very limited. Even more limited is the knowledge about species ecology and behaviour. Many of the species sampled on M61-1 have been documented alive for the first time.

In the following, some first results, focusing on faunal highlights are presented:

**Foraminifera**

<u>Komokiacea</u> Relatively large sized unicellular benthic organisms build up of cytoplasm surrounded by agglutinated material (Fig. 1.28a). Mostly reported from deep-sea habitats. This group is classified within the foraminifera. Members of this group have been found to be the main builders of the characteristic fluffy coverage of exposed dead coral framework (Fig. 1.28b). Komokiacea have also been found on other hard substrate during M61-1.

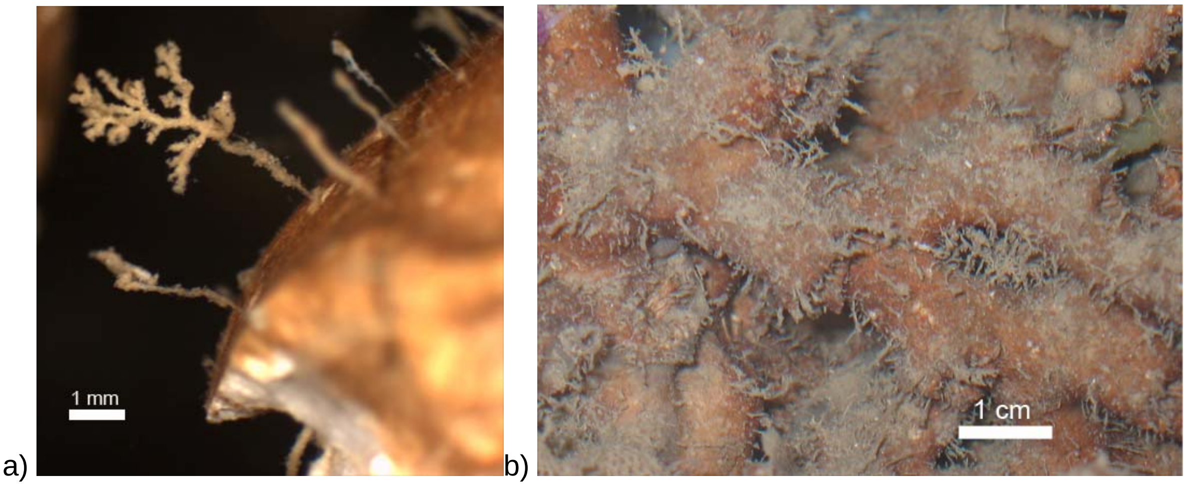



**Fig. 1.28:** a) Komokiacea, very frequent hair-like epifauna on dead coral, large specimen 4mm. b) Branch of dead *Lophelia pertusa* densely covered by unidentified komokiaceans.

**Porifera**

Several large and well-preserved specimen of the hexactinellid sponge *Aphrocallistes bocagei* (Fig. 1.29a) have been sampled (see benthic sample protocol for stations 215, 216, M61-1-217, 218, 221, 222, 223, 224, 225, 226, 240, 241, 259, 272, 317, 318). This species turned out to be one of the most common sponges in deep-water coral habitats of both the Porcupine-Seabight and the Western Rockall Bank. Dead sponges were often used as substratum mainly by a typical yellow-coloured species expanding into the skeleton of *Aphrocallistes*). A bright yellow non-agglutinating zoantharian species appeared to grow exclusively on *Aphrocallistes*. Another hexactinellid sponge, *Mellonympha velata*, was found in the sample M61-1-215 (Fig. 2b). This species is relatively rare compared to *Aphrocallistes*. A large number of small-sized sponge species is present and awaits further investigations by sponge taxonomists.

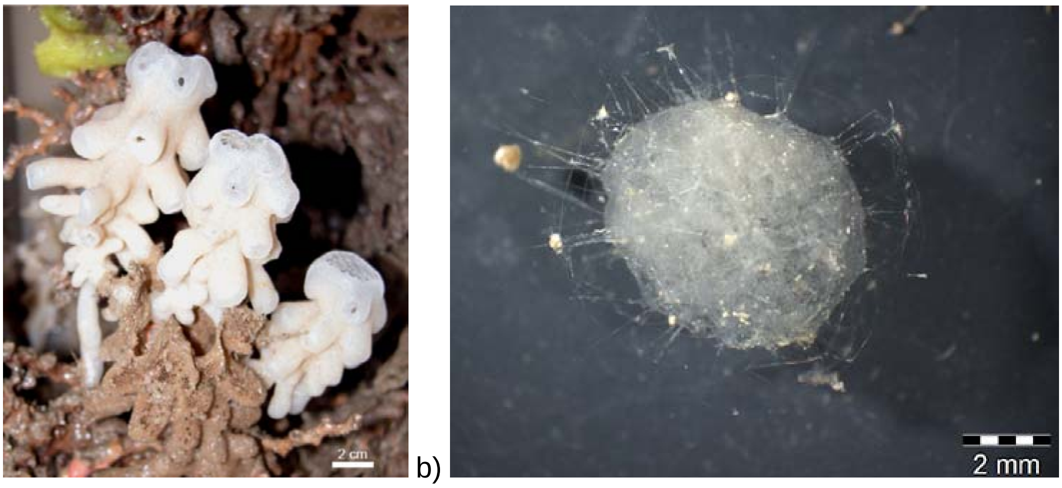
a) b)



**Fig. 1.29:** a) Three juvenile *Aphrocallistes bocagei* settling on a subfossil *Aphrocallistes*, height about 10 cm. b) Hexactinellid sponge ?*Mellonympha velata,* often growing in clusters of several species, may reach 12 cm in height.

**Cnidarians**

Hydroids A large number of densely branched non-calcified hydroids are found as epifauna on *Lophelia* and *Madrepora* frameworks as well as on dropstones (Fig. 1.30a). In samples from the dropstone habitats also stylasterids (calcified hydroids) were present (Fig. 1.30b). The colonies of *Pliobothrus symmetricus* were big enough to be also identified from OFOS imagery. In sample M61-1-223, one specimen showed typical feeding traces of the parasitic gastropod *Pedicularia sicula* (see benthic sample protocol for stations 215, 223, 225, 226, 238, 241, 242, 276). In some coral samples other stylasterids (*Stylaster* sp.) were growing on dead coral skeleton (see benthic sample protocol for stations 300, 309, 311).

Zoantharians A brownish stolonial species that normally agglutinated a lot of particles commonly occurs on each kind of hard substrate. *A. bocagei* skeletons were sometimes settled by a yellow-coloured species, which seem to be restricted to that special substrate (Fig. 1.31a).

Actinians Several coral samples contained actinians. Most frequent was a small species (<3cm) of soft consistence and pale reddish/pink colour. Another species formed dense clusters growing on coral fragments. This small actinian (<3cm) is recognizable by its orange to red mouth plate and the compact growth form. It is related to the genus *Nemanthus* (Fig. 1.31b).

Scleractinians *Lophelia pertusa* and *Madrepora oculata* were the most frequently encountered species in all benthic samples (Stat.-No: 215, 216217, 218, 221, 222, 223, 224, 225, 226, 238, 239, 240, 241, 242, 243, 259, 260, 264, 266, 273, 275, 276, 277, 300, 301, 305, 306, 309, 313, 317, 319). The solitary corals *Desmophyllum cristagalli, Caryophyllia sarsiae* und the worm-like *Stenocyathus vermiformis* were frequently present in the sediment samples (for solitary corals see benthic sample protocol for stations: 215, 216, 221, 223, 224, 225, 226, 241, 242, 259, 260, 264, 273, 274, 277,300, 301, 305, 309, 313). Living specimens were very rare.

Only once (Stat. 274) few *Fungiacyathus fragilis* and *Flabellum macandrewi* (Fig. 1.32a) have been found.

Antipatharians A very fragile branched species probably of the genus *Parantipathes* (Fig. 1.32b) was sampled on station 264.

Alcyonarians Some specimens of the stolonial species *Anthothela grandiflora* were sampled (Fig. 1.32c) (Stat. 225, 259). This species is very spectacular because of its intense purple colour and also has been documented with the OFOS system.

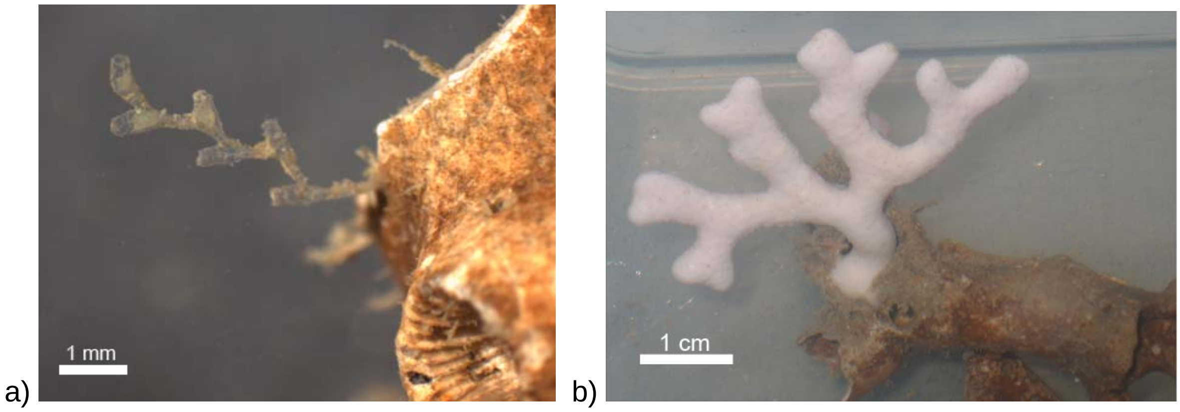



**Fig. 1.30:** a) Unidentified hydroid colony, epifaunal on dead coral, 4 mm in length, M61-1-223. b) *Pliobothrus symmetricus*, most characteristic feature of the dropstone habitat, colony 4 cm high.

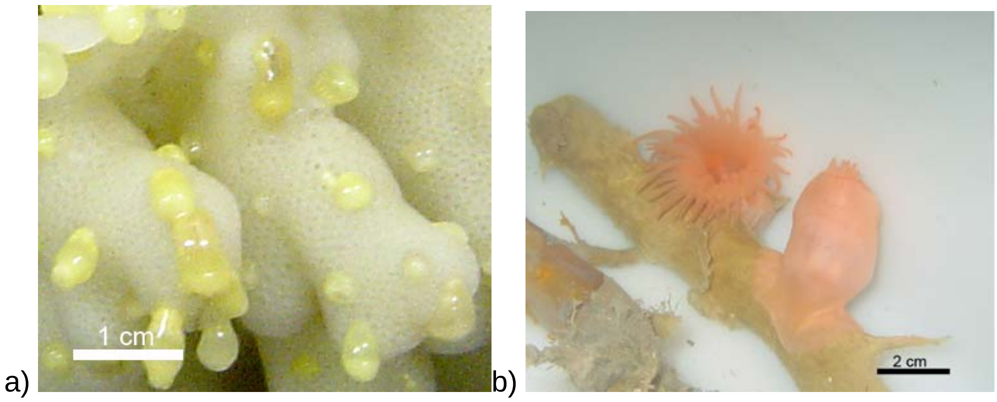



**Fig. 1.31:** a) *Aphrocallistes bocagei* settled by yellow zoantharians only found on *Aphrocallistes* (M61-1-225). b) Unidentified actinian (?*Nemantus* sp., with typical orange-red mouth plate, often forms dense clusters on dead coral, 2-3 cm in diameter.

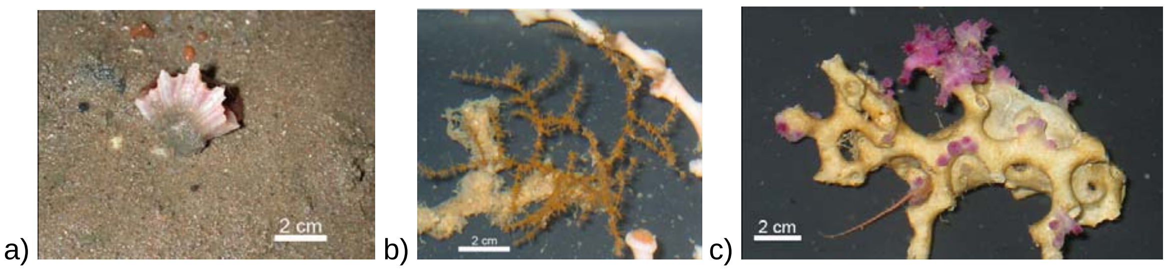



**Fig. 1.32:** a) *Flabellum macandrewi*, this solitary coral is living on soft sediment. M61-1-274. b) fragile antipatharian, probably *Parantipathes* sp., Belgica Mound station M61-1-264. c) *Anthothela grandiflora*, "stolonial" alcyonarian growing on dead coral framework. M61-1-225.

Gorgonians Several specimens of the species of *Acanthogorgia armata* and *Paramuricea* sp. have been sampled (Stat. 216, 217, 225, 259, 264). Different amphipods and Solenogastres are associated with these species indicating a mutual relationship between the hosting gorgonian and the associa-ted species (Fig. 1.33). There has been no indication for the presence of parasitic amphipods. One unidentified gorgonian was sampled. Subfossil fragments only represented the group of the Isidiids. However, living isidiid corals were frequently documented on Kiel Mount with OFOS.

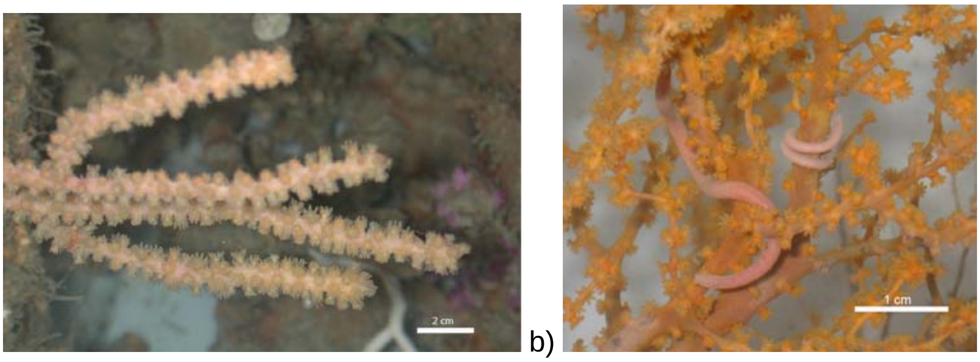
a) b)



Fig. 1.33: a) *Acanthogorgia armata*, frequently occurring in coral habitats, specimen 15 cm high, M61-1-225. b) *Acanthogorgia armata* (gorgonian) with associated Solenogastres. Caught in MOCNESS station M61-1-234.

**Molluscs**

The following species were found in almost every sample from coral habitats: *Addisonia excentrica, Alvania cimicoides* (Fig. 1.34a)*, Alvania jeffreysi* (Fig. 1.34b)*, Alvania zetlandica, Amphissa acutecostata* (Fig. 1.34c)*, Anatoma crispata, Asperarca nodulosa* (Fig. 1.34d)*, Astarte sulcata, Boreotrophon clathratus* (Fig. 1.34e)*, Calliostoma* cf. *leptophyma , Chlamys sulcata, Delectopecten vitreus* (Fig. 1.34f)*, Emarginula* cf. *christiaensi, Heteranomia squamula, Hiatella arctica, Iphitus tuberatus* (Fig. 1.35a)*, Propilidium exiguum, Pseudosetia turgida, Puncturella noachina, Pyrunculus ovatus, Strobiligera* sp. and *Talassia dagueneti.* Also living specimen of all these species were found and documented! We regard these 22 species as characteristic for the coral habitat in all the different study sites. For some of the cited species also their specific faecal pellets were documented (Fig. 1.35b-d). The majority of the “coral species” are gastropods. There are many particularly small species that seems to be specially adapted to this habitat. Most of the small species are detritivorous or feeding on foraminifera. The larger species either feed on Porifera or other sessile animals. Only few species are carnivorous like *Boreotrophon clavatus.* Several eulimids were found. Preliminary identification was only possible for some specimen belonging the genus *Fuscapex.*(Fig. 1.35e). Only one gastropod species was found which probably feeds on scleractinians. *Iphitus tuberatus* is not yet known by direct observation to feed on scleractinians. Other species of the genus *Iphitus* are known to be parasites.

Several authors suggest a relationship between *I. tuberatus* and scleractinian corals (Taviani & Sabelli, 1982; Bouchet & Warén, 1986). Bouchet & Warén (1986) namely mentioned *Lophelia*. Onboard, a small experiment has been carried out. Several of the living *Iphitus tuberatus* specimens were kept in small containers together with pieces of living *Lophelia* and *Madrepora*. During one week of observation, no obvious interest of *Iphitus* to approach the living parts of the corals has been documented.

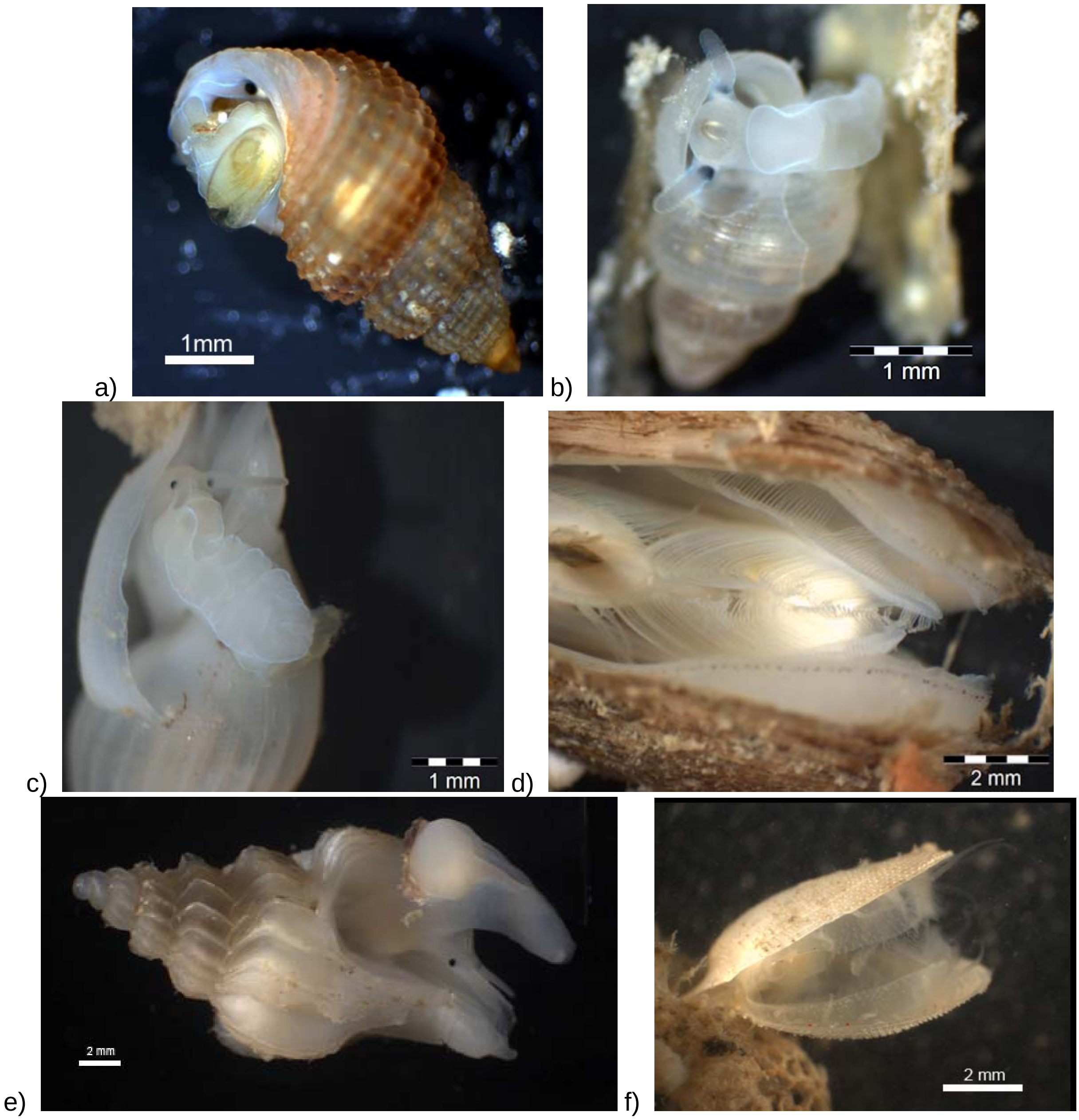



Fig. 1.34: a) *Alvania cimicoides*, 3.5 mm. This is the commonest rissoid gastropod in coral habitats, M61-1-234. b) *Alvania jeffreysi* one of the most frequent gastropod species in the coral habitat, 2 mm, M61-1-234. c) *Amphissa acutecostata* the most frequent gastropod in all samples, up to 7 mm. M61-1-272. d) *Asperarca nodulosa* (bivalve). Detail of soft parts, note the branchiae and the eyes, body size 1.4 cm. Present in all coral samples. e) *Boreotrophon clathratus*, 1.3 cm, carnivorous species, only found alive in M61-1-234. f) *Delectopecten vitreus* (Pectinidae), very common in coral habitats, 1.4 cm, M61-1-225.

The sampling on Kiel Mount brought up some spectacular findings. Marco Taviani identified several mollusc species alive that were described only from the early Pleistocene bathyal coral deposits at Messina, Sicily, some 2 Million years ago. The most spectacular findings were several specimens of a very characteristic cone-shaped limpet caught on station M61-1-300, attributed to genus of *Fissurisepta*. This species seems to be *F. rostrata* Seguenza, 1862, which has been described from Pleistocene bathyal coral deposits from Sicily (Fig. 1.36a). Since the description in 1862, this species has been reported only once by Jeffreys (1882).

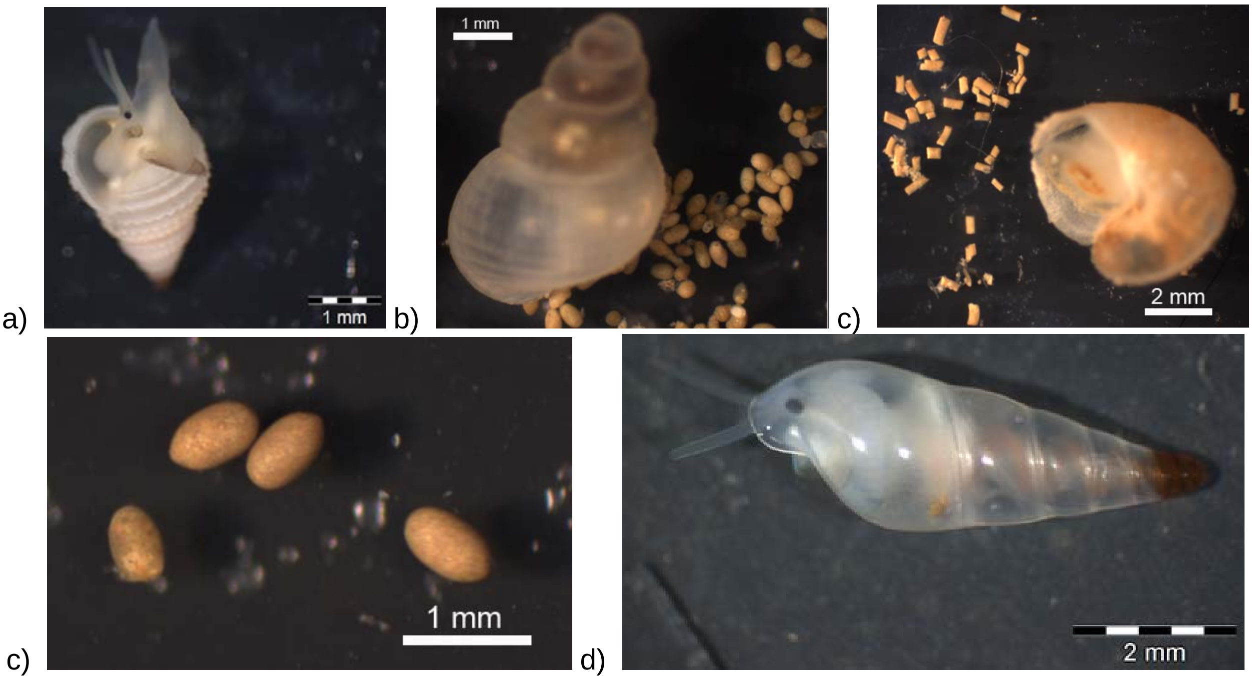



**Fig. 1.35:** a) *Iphitus tuberatus*, 2 mm, possibly parasitic on corals, M61-1-234. b) *Alvania jeffreysi* with faecal pellets, shell 2,3 mm, M61-1-234. c) *Anatoma umbilicata* with fecal pellets, M61-1-234 d) Faecal pellets of *Alvania cimicoides*. e) *Fusceulima* sp., eulimid gastropod parasitic on echinoderms, characterised by its brownish protoconch, M61-1-234.

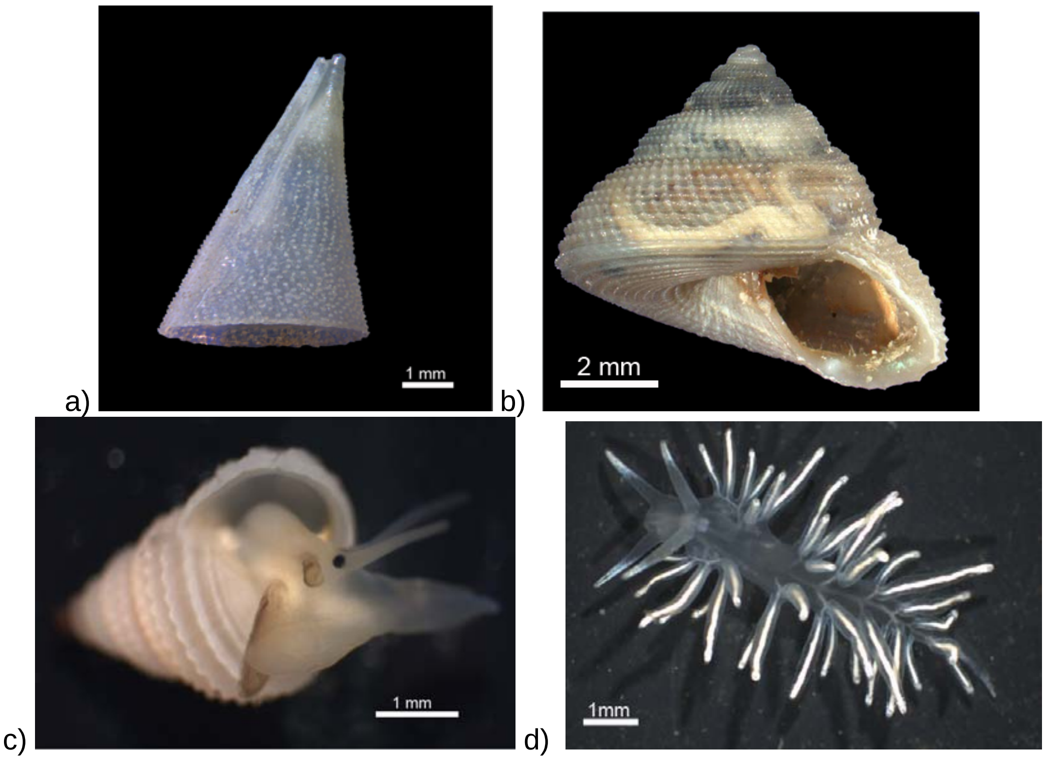



**Fig. 1.36:** a) *Fissurisepta rostrata*, large specimen 4 mm high. Since it's description by Seguenza this species only has been reported once in European waters. Found in sample M61-1-300 on Kiel Mount. b) *Ancistrobasis reticulata*, a very rare species, several findings have proven the presence of healthy populations at least on Rockall Bank. M61-1-234. c) *Iphitus tuberatus*, 2 mm, possibly parasitic on corals. M61-1-234. d) Unidentified Nudibranch (Gastropoda), 5 mm, only this specimen found. Little Galway (Belgica) Station M61-1-218, 871 m.

From a bio-geographical point of view the repeated finding of living *Ancistrobasis reticulata* is noteworthy (Fig. 1.36b). This species seems to be present in well-installed populations on Western Rockall Bank as well as in the Porcupine Seabight. The occurrence in the study areas is an important extension of its previously known range. *Ancistrobasis reticulata* is usually living in the western parts of the Atlantic and elsewhere was reported only with a single specimen from Iceland (Warén, 1991) .

Another uncommon gastropod, the caenogastropod *Talassia dagueneti* was also found alive (Fig. 1.36c). This species has not yet been found so far north (pers. comm. A. Warén). Several findings of living specimens are supporting the presence of a healthy population in the Porcupine Seabight. At station 218 from Little Galway Mound the only nudibranch was found (Fig. 1.36d).

**Polychaetes**

Polychaetes were represented in almost all the benthic samples. In coral samples many different species were present. The most striking species is the large *Eunice norvegica* that reaches up 20 cm in length (Fig. 1.37a-c). This species lives closely associated to the colonial scleractinians *Lophelia* and *Madrepora*.

Almost no coral colony has been found without *Eunice* being present. A very characteristic reddish Polychaete of the family Hecionidae was also present in nearly all samples containing dead or living coral (Fig. 1.37d). In some boxcore samples from the Belgica area, another large species was found. This species resembles *Eunice norvegica* but is bigger (up to 25 cm) and of brownish colour. It always was found burrowed in the sediment. On dropstones and coral framework, a large number of serpulids were found. Attached to larger pieces of dead coral framework u-shaped tubes of a chaetopterid worm was found, some of them were still containing the animal. This species has only been found in samples from the western Rockall Bank.

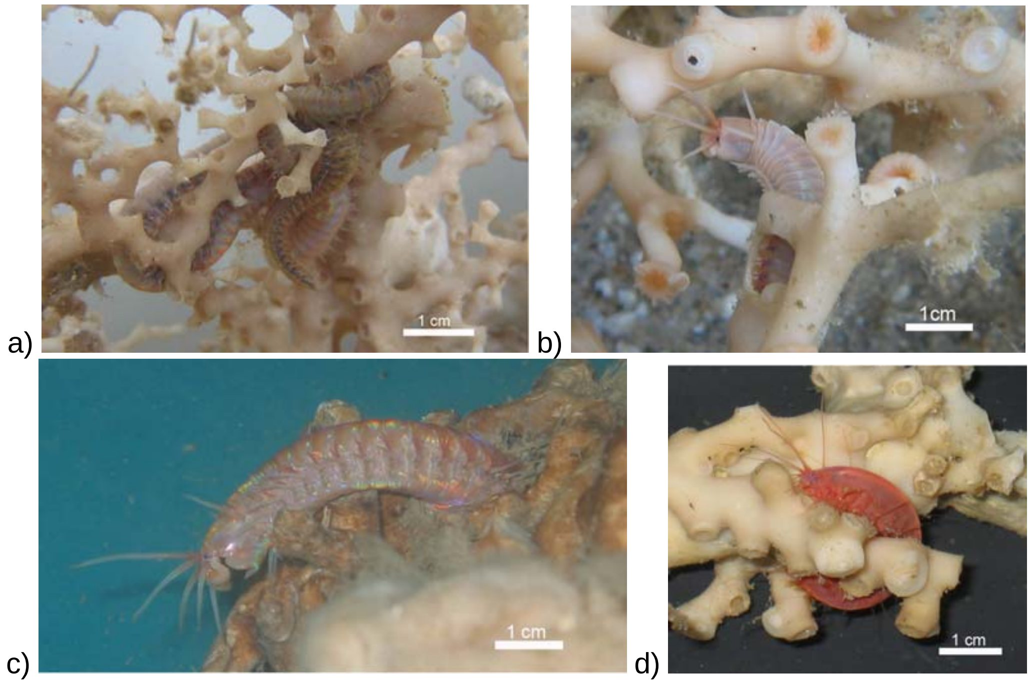



**Fig. 1.37:** a-c) *Eunice norvegica*, large polychaete that may reach 20 cm (a), co-occurring in close association with with *Lophelia* (d) and *Madrepora* (a). d) Not closer identified hecionid polychaete, beside *Eunice* the by far most frequent large polychaete in coral habitats, 4 cm.

**Crustacea**

A large number of different, not further identified cumaceans (Fig. 1.38a), amphipods (Fig.1.38b and c), isopods and caprellids (Fig. 1.38d) were found in various samples. The distinctive amphipod species *Epimeria tuberculata* was a rather common one in the Belgica Mound Province. The species of Epimeria are very opportunistic and feeding on each kind of prey. A frequent brachyuran species in coral samples was *Bathynectes maravigna* (Fig. 1.38e), a portunid crab. Squatlobsters (*Munida* sp.) (Fig. 1.38f) were also caught in various samples. Two different balanids (cirripeds) has been encountered. *Verruca stroemia* is frequently growing on all kind of hard substrate. Another species, presumably *Bathylasma* sp. is a most characteristic feature of the dropstone habitats.

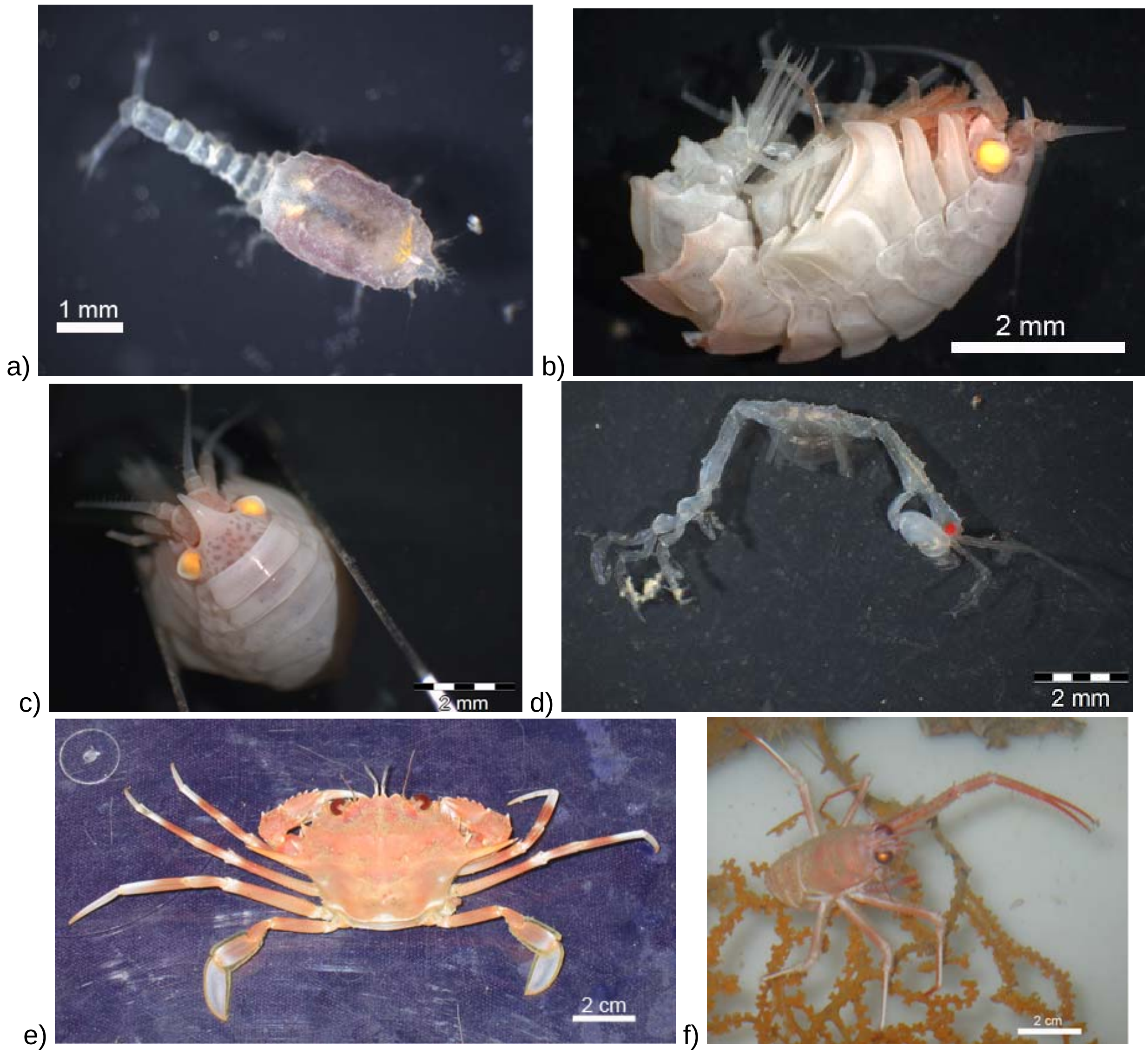



**Fig. 1.38:** a) Unidentified cumacean frequently found in sieved fractions >0.5 mm, 3 mm in length. M61-1-273. b+c) *Epimeria tuberculata*, 4 mm, rather common in samples from the Belgica province, M61-1-224. c) Detail: Head and eyes. d) *Bathynectes maravigna*, portunid crab, common in coral habitats, carapax 3 cm in diameter. M61-1-225. f) Squatlobster (*Munida* sp.), 5 cm in length, often hiding under coral framework. M61-1-234.

## Echinoderms

Echinoderms were found frequently. The echinoid *Cidaris cidaris* was a common species in many samples. Very often its large spines reported its former presence. One specimen of the genus *Echinus* was sampled (Fig. 1.39a) on station M61-1-225. Unstalked crinoids of a not closer identified species were found sitting on top of dead coral framework or *Aphrocallistes* (Fig. 1.39b) (M61-1-305, M61-1-306). Few starfish were caught in the sediment samples. *Ceramaster* sp. (Fig. 1.39c) and *Porania pulvillus* (Fig. 1.39d) were the only species sampled.

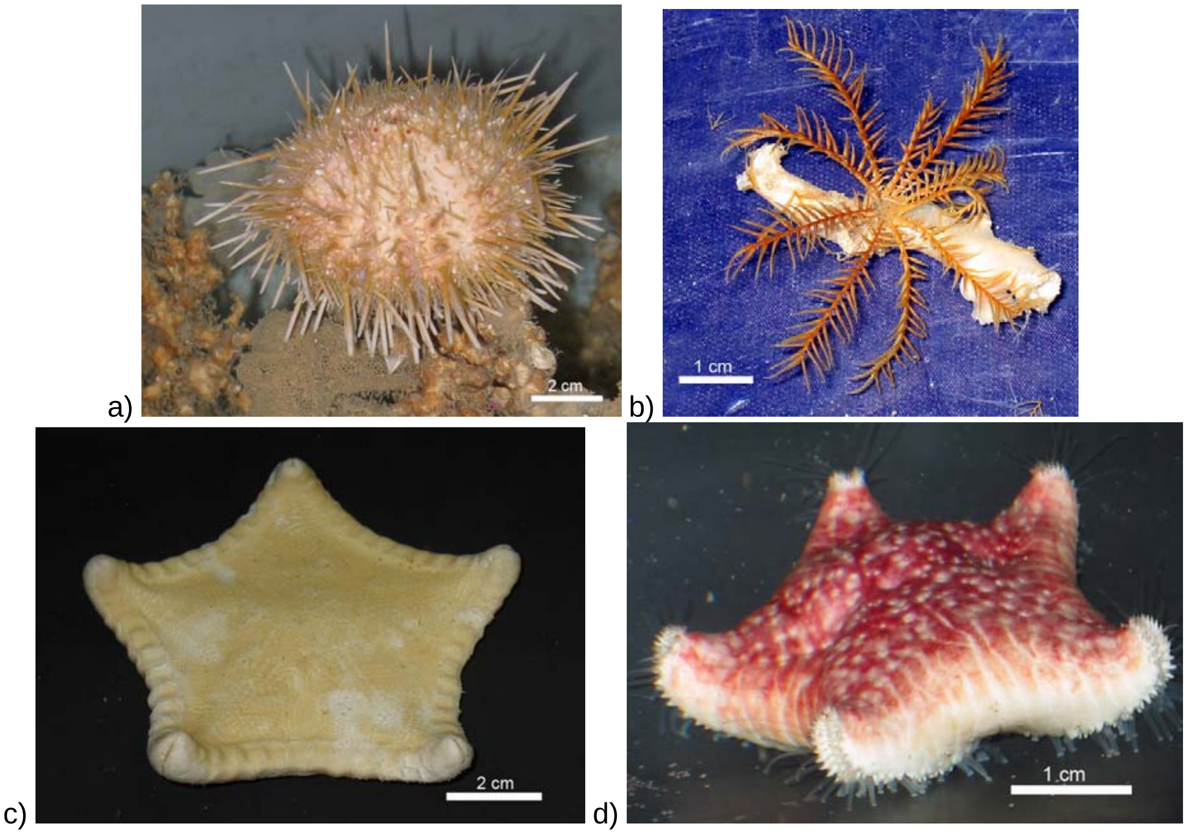



**Fig. 1.39:** a) *Echinus* sp. One of the largest sea urchin in coral habitats, 7 cm, M61-1-225. b) Unstalked crinoid unidentified, diameter 6 cm. M61-1-305. c) *Ceramaster* sp. common starfish in coral habitats in the Porcupine Seabight, 7 cm, M61-1-234. d) *Porania pulvillus*, cushion starfish, feeding on dead coral epifauna, 4 cm, M61-1-234.

## Brachiopods

Small brachiopods living attached to coral framework were common throughout the study area (mainly *Neocrania anomala* and juvenile *Terebratulina* sp. (Fig. 140a).

## Bryozoans

Bryozoans were in all samples one of the most important groups growing on various hard substrates. Cyclostome bryozoans showed to be the dominant group on dead coral framework (Fig. 1.40b).

## Pterobranchia

The very characteristic dark coloured stolonial network of *Rhabdopleura normani* was regularly found on dead coral pieces.

a) 

b) 


Fig. 1.40: a) juvenile brachiopod of the genus *Terebratulina*, note the faecal pellets. This species is a frequent feature in dead coral epifauna, M61-1-221. b) Very fragile specimen of a cyclostome bryozaoan. Height of the colony is 2.5 mm. M61-1-221.

### 1.4.10 Megafauna Documented with the OFOS System: First Trends

(Freiwald, A., Beck, T., Vertino, A.)

The megafauna data obtained from the OFOS system provide a first impression of the presence and abundance of organisms larger than 10 cm body size in the cold-water coral ecosystem. It is a valuable tool to document the megafauna of cold-water coral ecosystems. The knowledge of the scale and the always downward-looking cameras will facilitate the statistical analysis of the megafauna in relation to benthic habitats and the sedimentary environment.

Based upon the onboard analysis of the megafauna from the OFOS video-tapes and the processed slides, five major groups are discernible: Porifera, Cnidaria, Arthropoda, Echinodermata and fish. A detailed taxonomic assessment will follow in the home laboratory.

**Porifera**

Sponges with a large body size originated from two major groups, the Hexactinellida (glass sponges) and the Demospongia (Fig. 1.41). The hexactinellid *Aphrocallistes bocagei* occurs very abundant in the deep coral-covered carbonate mounds of the BMP (Castor Mound and Pollux Mound) (Fig. 1.41a). Few *A. bocagei* were noted on the Erik Mound. In the WRB, this species was observed rarely on Franken Mound. In all cases documented, *A. bocagei* uses dead coral colonies as a hardsubstrate. The silicate skeleton is pale white or greenish-brown when the sponge is dead. Large specimens measure 25 cm in height. In a number of slides, small yellow spots are visible on the tubular-branching skeleton of *A. bocagei*. These objects turned out to be actinians that settle upon the sponge skeleton (see section of macrofauna).

Demospongia are more diverse, but large specimens are quite rare in the BMP. On Castor Mound, some 10 cm-high white sponges with an external meshwork of megascleres colonise life and dead corals (Fig. 1.41b). A yellow encrusting sponge was often documented settling on dead coral colonies on Castor Mound (Fig. 1.41c). The highest diversity of sponges, however, was recorded on Kiel Mount. The basalt outcrops are densely covered by *Phakellia*- or *Axinella*-type sponges (Fig. 1.41e) and are locally associated with branched sponges, which may represent *Antho* sp. (Fig. 1.41f). On shelly substrates, an up to 20 cm high cup sponge with a wide osculum was commonly found (Fig. 1.41d). The sponge community on Kiel Mount strongly resembles those from the Logachev Mound Province, on the other side of Rockall Bank (Freiwald, 2002).

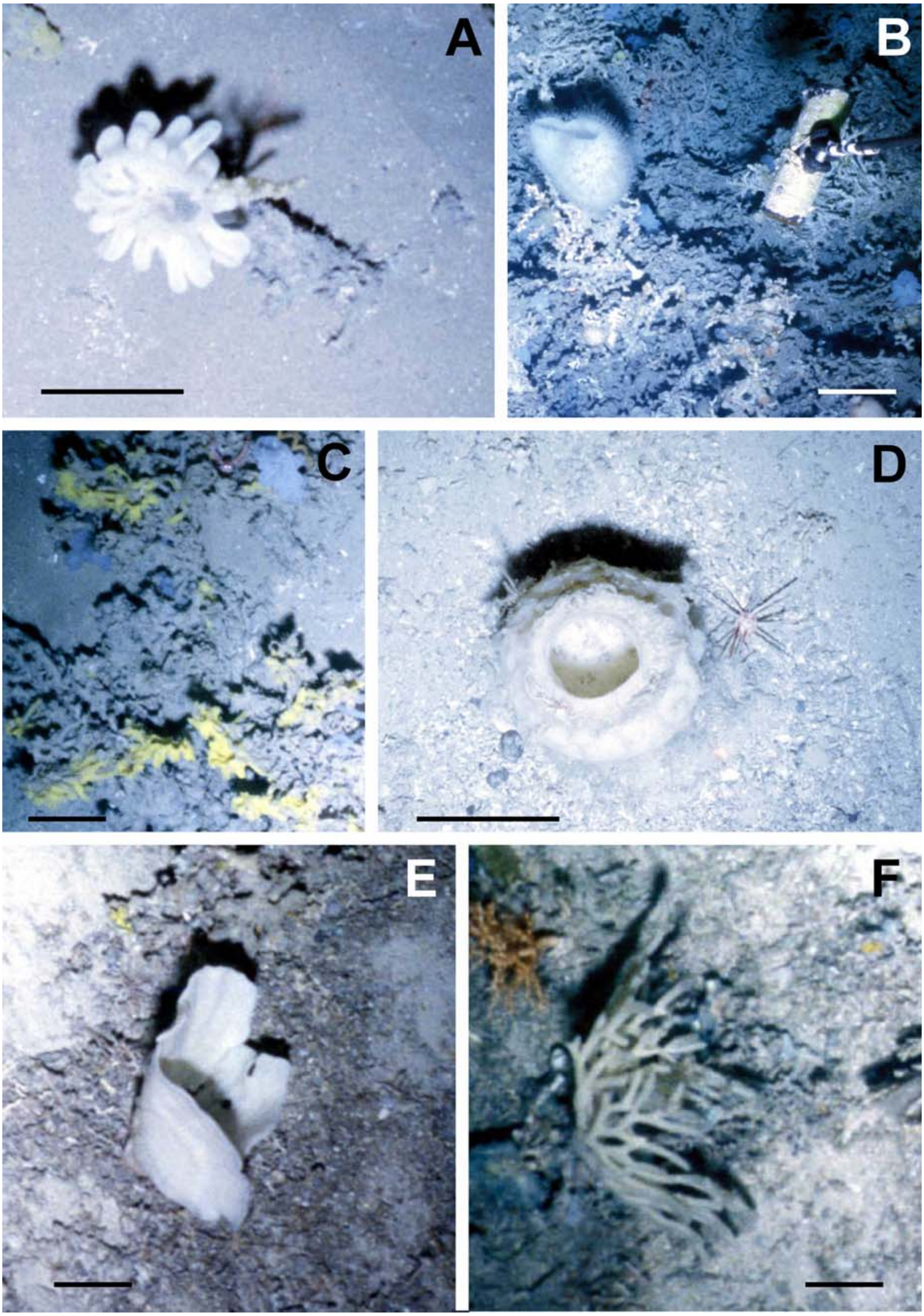



**Fig. 1.41:** Megafauna Porifera.: a) *Aphrocallistes bocagei* (Castor Mound), b). Sponge with a meshwork of external megascleres (Castor Mound), c). Yellow dead coral-encrusting sponge (Castor Mound, d). Large cup-shape sponge (Kiel Mount), e) Fan-shaped sponge (Kiel Mount), f) Branched sponge *(Antho?* sp., Kiel Mount. All scale bars represent 10 cm length.

**Cnidaria**

The most diverse megafauna group are the cnidarians which are represented by hydroids, actinians, scleractinia, octocorals and antipatharians (Figs. 1.42-1.45).

Hydroids Thecate hydroids were only observed on Franken Mound. The small tree-like colonies grow directly upon a limestone crust and may represent *Nemertesia* sp. (Fig. 1.42b). More common are stylasterids. The calcified hydrocoral *Pliobothrus symmetricus* is confined to dropstone pavements in the gulleys adjacent to the carbonate mounds, were strong currents have prevented sedimentation since the time of IRD release to the seabed (Fig. 1.42a and e). The colonies rarely exceed 6 cm in height and are dichotomously branched. *P. symmetricus* was seen on OFOS images in the BMP area (Castor Mound, Erik Mound) and at the deep slope of Kiel Mount, WRB. The larger genus *Stylaster* sp. was found alive only in the coral thickets of Franken Mound (WRB). Huge (>30 cm) fossil colonies of *Stylaster* sp. were photographed on large boulders at the foot of Kiel Mount.

Scleractinians The prime target of M61-1 was the documentation of environmental conditions of the framework-constructing corals *Lophelia pertusa* and *Madrepora oculata* (Fig. 1.42c and d). These two species were found on any location surveyed with the OFOS system. Most active growth in the BMP of these azooxanthellate corals takes place on Castor Mound, preferably around the upper slopes and the summit. Further upslope life coral coverage decreases continuously when comparing the results of Castor Mound, Pollux Mound and Erik Mound. The developmental stage of the coral framework rarely exceeds that of a thicket stage. A thicket is characterised by less than 1 m-thick coral framework growth and debris accumulation during the entire Holocene. Reef framework (> 1 m thickness) was not observed on M61-1. Interestingly, even in actively growing coral thickets, the percentage coverage is relatively low (quantified data will be statistically analysed at a later stage). This also fits with OFOS documentations of the large coral thickets on Franken Mound (WRB). There is strong evidence, that ongoing larval settlement of both the framework-constructing corals is ongoing (Fig. 1.42d). Solitary scleractinians have been recorded on Joe's Nose *(Flabellum macandrewi)* and Kiel Mount *(Caryophyllia* cf *sarsiae, Desmophyllum cristacalli, Flabellum macandrewi).*

Actinians Actinains are quite diverse but are generally difficult to identify on OFOS images. Common soft bottom dwellers on muddy to coarse sands are the so-called cylinder roses, or, cerianthiids, with their long and thin tentacles (Fig. 1.43a). This group primarily is found in any off mound environment. The large actinian *Bolococera tuediae* was only found muddy and unrippled off mound sediments (Fig. 1.43f). On Franken Mound, a reddish-brown not yet identified actinian colonises dropstone boulders at a very localised spot (Fig. 1.43b). A notable finding was the very abundant occurrence of *Actinauge* sp. on the entire southern slope of Castor Mound (Fig. 1.43d). This actinian has a sac-like body of white colour measuring 5 – 6 cm when erected. The upper external wall of this species is structured by large knobs. Both the oral disc and the tentacle crown are intensely red-coloured. If present, it occurs in large aggregations on dead coral colonies. This actinian has only been found on coral limestones in the Pelagia Mound Province, southeastern Rockall Trough. A more widespread and common actinian in all areas surveyed is a large (>15 cm) species with an umbrella-like oral disc surrounded by relatively short tentacles. Both the oral disc and the tentacles are orange coloured. Although, we have to confirm the taxonomic status of this species, it may well be *Phelliactis hertwegii* (Fig. 1.43e). This species is attached to dead corals and, rarely, to boulders.

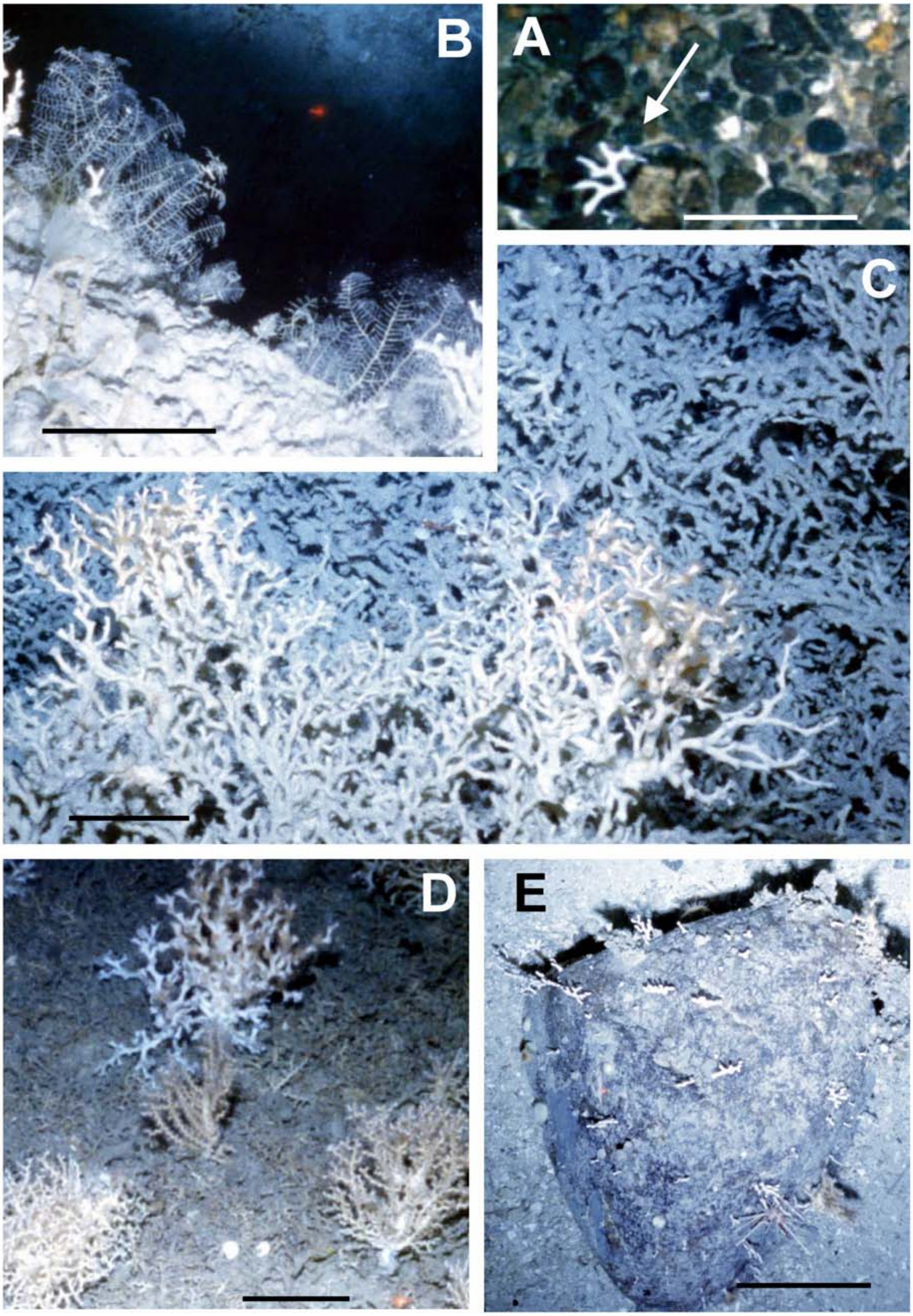



**Fig. 1.42:** Megafauna Cnidaria I: a) *Pliobothrus symmetricus* (arrow) growing on a dropstone pebble (Erik Mound), b) Thecate hydroid colonies, probably *Nemertesia* sp. (Franken Mound), c) Coral thicket consisting of *Lophelia pertusa* (Franken Mound), d) Recently settled *L. pertusa* (central) and *M. oculata* (right) colonies (Franken Mound). e) Several *P. symmetricus* on a boulder (Kiel Mount). Scale bars represent 10 cm.

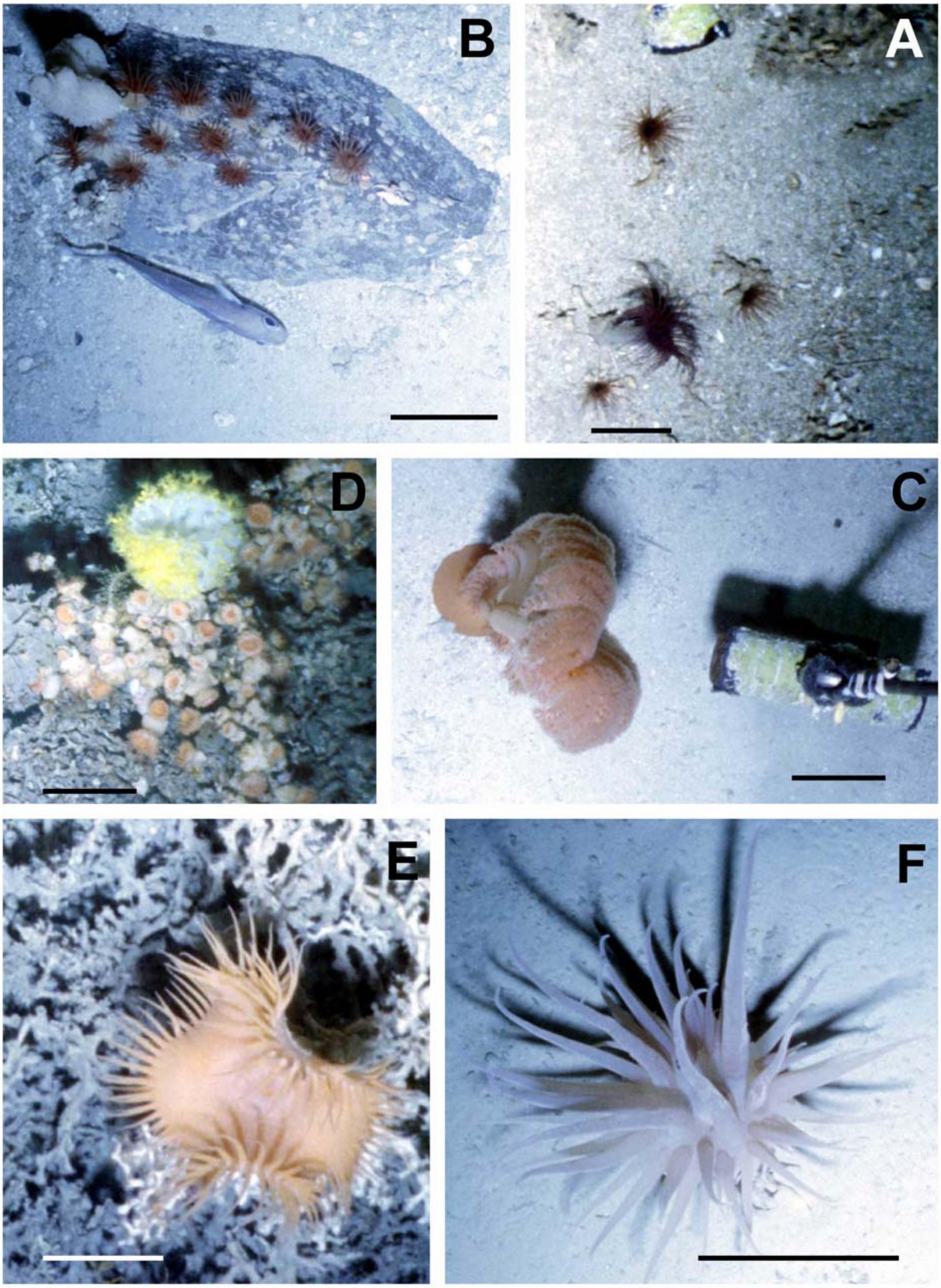



**Fig. 1.43:** Megafauna Cnidaria II: a) Ceriantiid actinians (Joe's Nose). b) A group of unidentified actinians living on a dropstone (Franken Mound), c) The sea pen *Pennatula* sp. (Kiel Mount), d) A cluster of *Actinauge* sp. (Castor Mound), e) Probably *Phelliactis hertwegii* with a folded oral disc (Franken Mound), F. *Bolocera tuediae,* a soft bottom dweller (Franken Mound). Scale bars refer to 10 cm length.

Octocorals Octocorals represent a diverse group amongst the megafauna. On soft bottoms, sea pens represented by a red *Pennatula* sp. are commonly distributed. Rich sea pen grounds were recorded from the upper slope and summit region of Kiel Mount (Fig. 1.43c). Another soft bottom dweller is a *Drifa*- or *Capnella*-like octocoral that was found in locally large numbers in the WRB only (Fig. 1.44e). One of the most common octocorals is the gorgonian *Acanthogorgia* cf. *armata* (Fig. 1.44b). On the summit of Castor Mound, this species forms extended meadows growing on dead coral framework. The purple octocoral *Anthothela grandiflora* was only documented from Pollux Mound (Fig. 1.44a). *Paragorgia arborea* was found in great numbers growing on boulders on Kiel Mount (Fig. 1.44c and d). Both, the red and white colourmorphs are present. This species was not recorded during earlier ROV-surveys in the region. Kiel Mount was also the only site were some isidiid bamboo corals were frequently observed (Fig. 1.44f and g).

A *Plumarella*-like gorgonian with a characteristic pinnate branching pattern was photographed several times on Kiel Mount (Fig. 1.45c). On Franken Mound, several yet not closer identified gorgonian or antipatharian colonies were documented (Fig. 1.45d and g). The strongly coiled species, however, was documented on any OFOS survey (Fig. 1.45e). The red brown antipaharian *(Parantipathes* sp., Fig. 1.45b) is widely distributed in the coral habitat and on boulders. This species is inhabited with decapod crabs *(Chirostylus* sp., Fig. 1.45b). A dark red antipatharian species with a dense polyp package was only observed on Kiel Mount (Fig. 1.45a). Almost all of the briefly introduced cnidarians have been sampled with grabs or box corers on M61-1 or on previous cruises to the carbonate mounds- and very often with their associated fauna. A network of taxonomic experts for bathyal cnidarians has been established and will add to the poor taxonomic and ecological knowledge of these groups in the NE Atlantic.

**Arthropods**

Amongst the arthropods, mostly decapod crabs are identifiable (Fig. 1.46). One of the largest species is *Paromola cuvieri* (Fig. 1.46a and b). This crab occurs in the coral thicket, on off mound muddy sand areas and on boulders. It carries sessile organisms such as sponges and gorgonians with its abdominal legs around. Another large crab is *Chaecon affinis* that was often documented scavenging food (Fig. 1.46c and d). Further examination of the video-tapes and still photographs will show us the kind of food. A somewhat smaller decapod is *Bathynectes maravignae* that shows an affinity to coral thickets (Fig. 1.46f). Barely visible on OFOS images, but the most abundant decapod is the squatlobster *Munida* sp. (Fig. 1.46e). *Munida* lives in burrows in the soft sedimentary facies in close proximity to the coral habitat.

*Chirostylus* sp. has been mentioned in the previous section. This species was documented only on antipatharian colonies, thus indicating a mutual relationship. Smaller arthropods generally are not identifiable from the OFOS images, except for barnacles that commonly occur together with the stylasterid *Pliobothrus symmetricus* in the dropstone-rich gulleys.

**Echinoderms**

Echinoderms are represented with the following classes amongst the OFOS megafauna assessment: Crinoidea, Asteroidea, Ophiuroidea, Echinoidea and Holothuridea. Crinoids, although not illustrated here, were noticed rarely in the BMP but are common on Kiel Mount. In most cases, the unstalked crinoids use elevated positions as resting places such as scleractinian, or gorgonian colonies. The comatulid crinoids belong to *Koehlermetra porrecta* and *Antedon* sp.

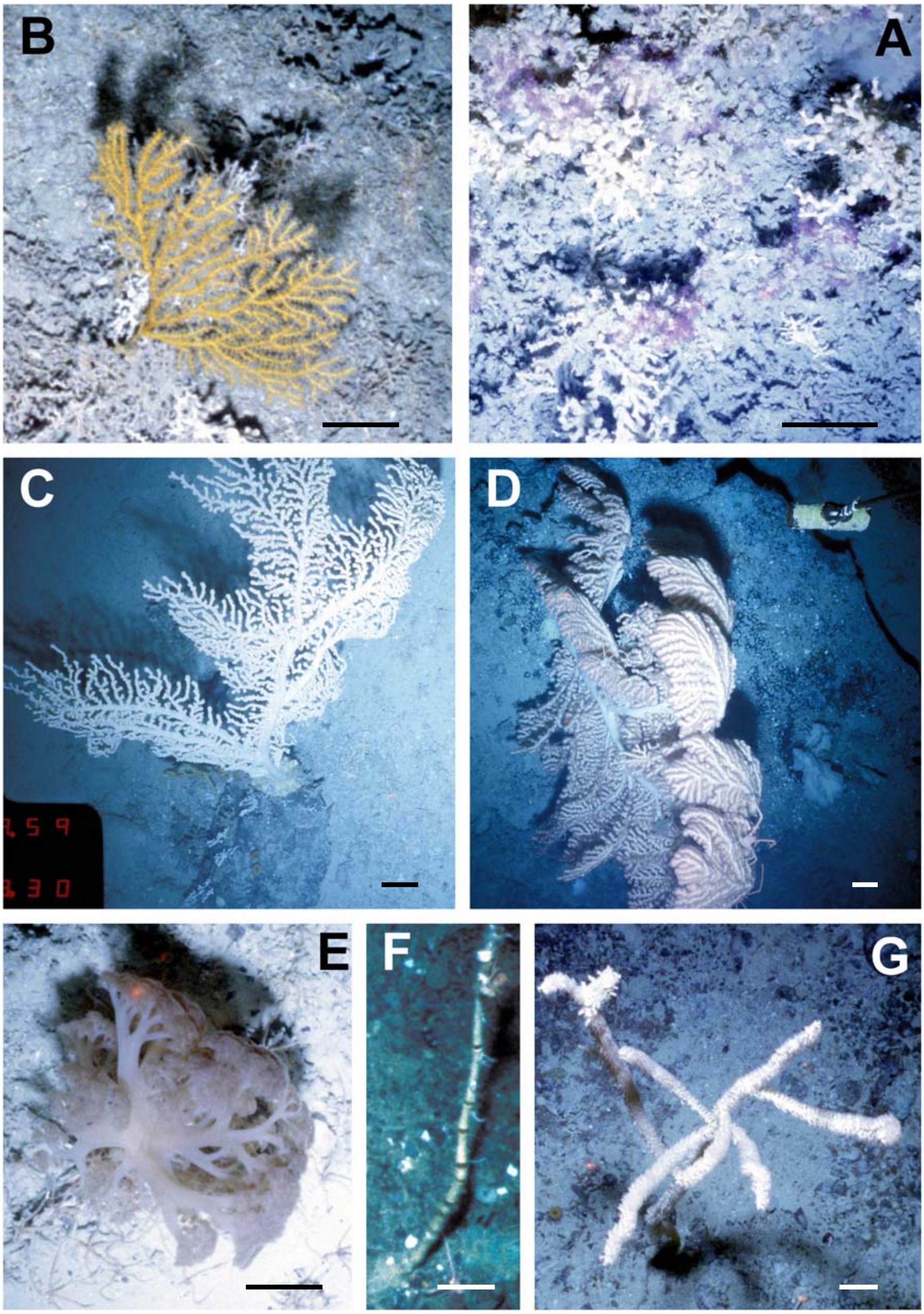



**Fig. 1.44:** Megafauna Cnidaria III: a) *Anthothelia grandiflora* (Pollux Mound), b) *Acanthogorgia* cf. *armata* (Erik Mound), c) White colourmorph of *Paragorgia arborea* (Kiel Mount), d) Red colourmorph of *P. arborea* (Kiel Mount), e) *Drifa* sp. or *Capnella* sp. (Franken Mound), f) Stem of a bamboo coral (Isidiidae, Kiel Mount), G. Live isidiid coral (Kiel Mount). All scale bars refer to 10 cm length.

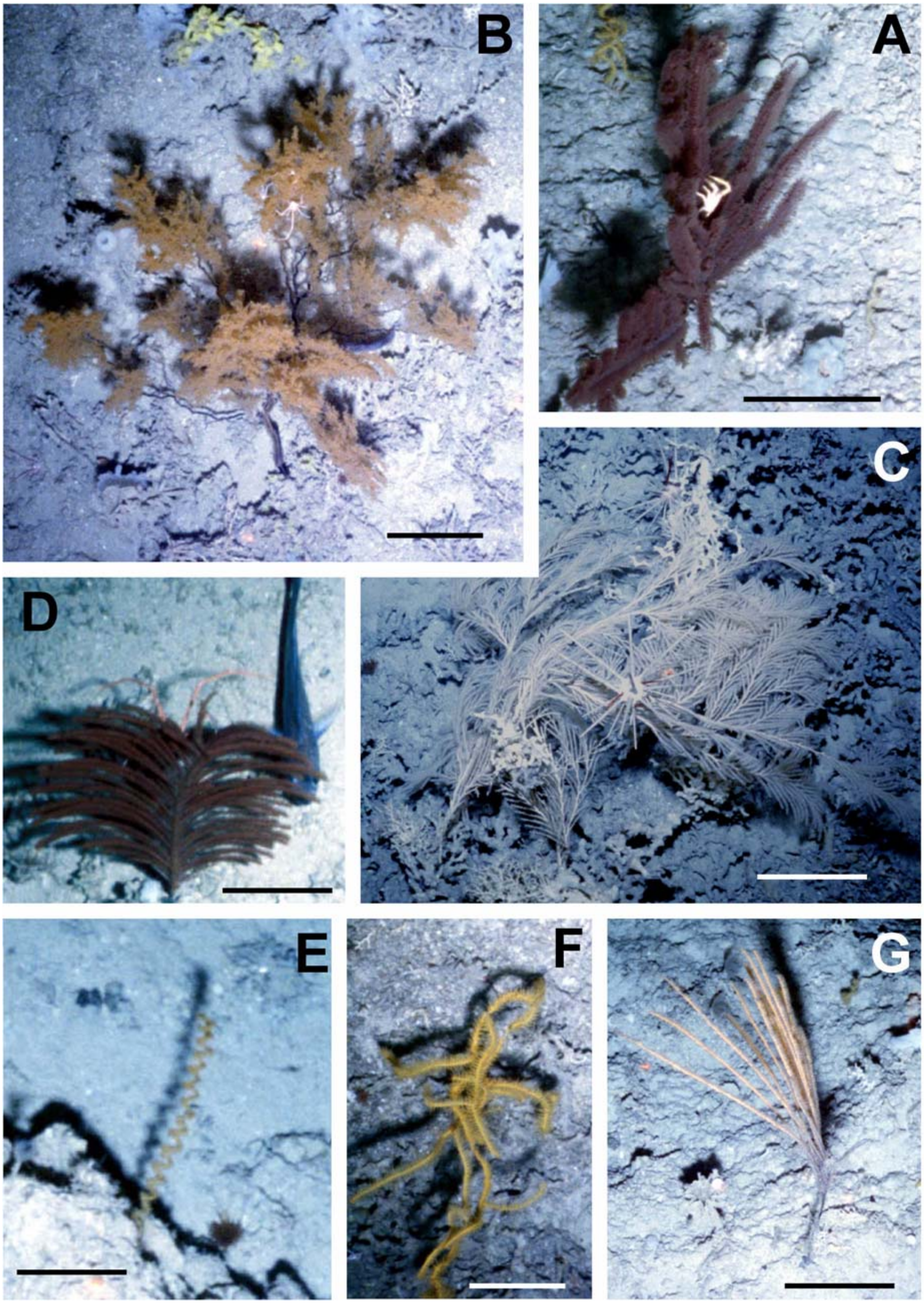



**Fig. 1.45:** Megafauna Cnidaria IV: a) *Parantipathes* sp. with the decapod *Chirostylus* sp. clinging between the branches of the antipatharian (Kiel Mount), b) unidentified antipatharian colony (Kiel Mount), c) *Plumarella* sp. was only found on Franken Mound, d) to g) unidentified gorgonian and antipatharian colonies from Kiel Mount. All scale bars refer to 10 cm length.

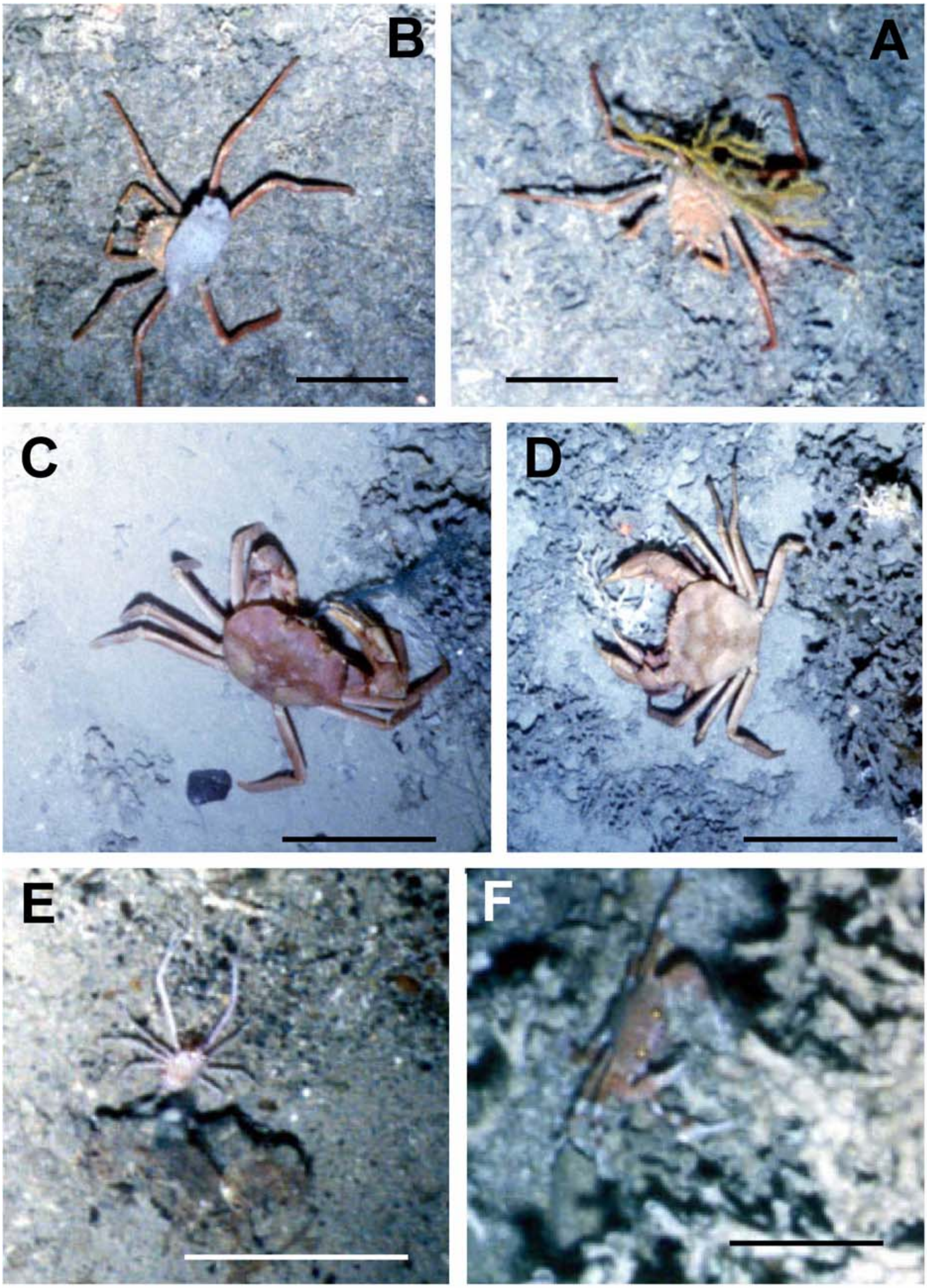



**Fig. 1.46:** Megafauna Arthropoda. a) and b) *Paromola cuvieri* carrying *Aphrocallistes bocagei* (b) and *Acanthogorgia* cf. *armata* with ist abdominal legs around (Erik Mound), c) and d) *Chaecon affinis* consuming food (Kiel Mount), e) The squatlobster *Munida* sp. (Kiel Mount), f) *Bathynectes maravignae* (Joe’s Nose). All scale bars refer to 10 cm length.

Asteroids are most abundant in the coral thickets and to a lesser degree in the off mound sandy environments. Most star fish species found in the coral habitat have a cushion-shape growth habit (Fig. 1.47a to d) and strongly resembles *Ceramaster* sp. (Fig. 1.47a and c) *Porania* sp. (Fig. 1.47b) and *Poraniomorpha* sp. (Fig. 1.47e). The latter species is mostly found crawling on living *Lophelia* and *Madrepora*. Pale red asteroids with 5 long arms and a small oral disk (Fig. 1.47f) seem to prefer the corals proximal off mound muddy sand areas.

Holothurians were abundant on muddy sand areas on and around Kiel Mount with *Benthogyne* as the major genus (Fig. 1.47h). Under contrast-rich illumination and shadowing effects, the small encrusting holothurians, *Psolus* sp., become detectable on OFOS images (Fig. 1.47g). The latter genus is confined to hardsubtrates such as boulders or coral colonies.

Epibenthic sea urchins show highest densities within the coral rubble and coral thicket facies. *Cidaris* cf. *cidaris*, however, was documented in any facies, regardless of off mound or on mound environments (Fig. 1.48a). More restricted to living corals is Echinus cf. acutus, a whitish urchin that occurs both in the BMP and WRB area (Fig. 1.48b). Some brownish to violet colourd echinothurids, probably represented by *Araeosoma* sp. (Fig. 1.48d), and *Hygrosoma/Sperosoma* sp. (Fig. 1.48c) were frequently encountered on Franken Mound.

Despite the almost ubiquitous occurrence of brittle stars, they are hardly visible on OFOS images, except for areas, were a strong colour contrast provided a clear view on a plain seabed. On the western upper slope of Kiel Mount, certain muddy sand sheets were densely populated by ophiuroids of a yet not identified species (Fig. 1.48e).

An orange-coloured sea urchin-shaped organism of yet not known origin was documented on Kiel Mount (Fig. 1.48f). It may well be a cnidarian but any hints are welcomed.

**Fishes**

The topographically complex carbonate mound and seamount habitats attract many bathydemersal fish species. Some of them were photographed with the OFOS system and are described and illustrated (Fig. 1.49). A rarely documented shark is *Oxynotus paradoxus,* the sailfin-roughshark (Fig. 1.49a). The biology of this species is poorly known. *O. paradoxus* is oviparous and preys upon benthic invertebrates in the bathyal zone. A more common shark found in the BMP and WRB is *Galeus melastomus*, the blackmouth catshark (Fig. 1.49b). This oviparous species feeds on benthic and midwater invertebrates. Skates are represented by *Bathyraja* sp. that we only could document on Kiel Mount (Fig. 1.49c). A very abundant fish is *Lepidion eques,* the North Atlantic codling (Fig. 1.49d). This bathydemersal fish feeds on crustaceans and polychaetes. The monkfish, *Lophius piscatorius,* was found laying in the coral rubble facies and on plain sandy substrates and is of highly commercial interest (Fig. 1.49e). *L. piscatorius* lies half-buried in the sediment waiting for its prey. It attracts mainly fishes by means of its fishing filament on the dorsal part of the head. Adult specimens can attain up to 2 m size. The blue ling, *Molva dypterygia,* was only found in the WRB in some quantities (Fig. 1.49f). This non-migratory, demersal fish feeds on crustaceans and small fish and is commercially fished. Fully grown specimens measure up to 1.55 m in length. The scorpenid fishes are represented by two species. *Trachyscorpia cristulata*, spiny scorpionfish, is commonly found on muddy or sandy habitats (Fig. 1.49g). The size varies from 15 – 55 cm. *T. cristulata* feeds on benthic crustaceans and cephalopods. The scorpenid blackbelly rosefish, *Helicolenus dactylopterus,* is a common species in both survey areas (Fig. 1.49h). It is found in soft bottom areas and in the coral habitat and feeds on both benthic and pelagic organisms (crustaceans, fishes, cephalopods and echinoderms). This species is of commercial interest.

The bathypelagic false boarfish, *Neocyttus helgae,* was found commonly on those mounds that are characterised by active coral growth and strong current velocities (Fig. 1.49i). *N. helgae* is frequent on Castor Mound and was much rarer on the shallower mounds. In the WRB, *N. helgae* is common on Franken Mound. The biology of this species is poorly known.

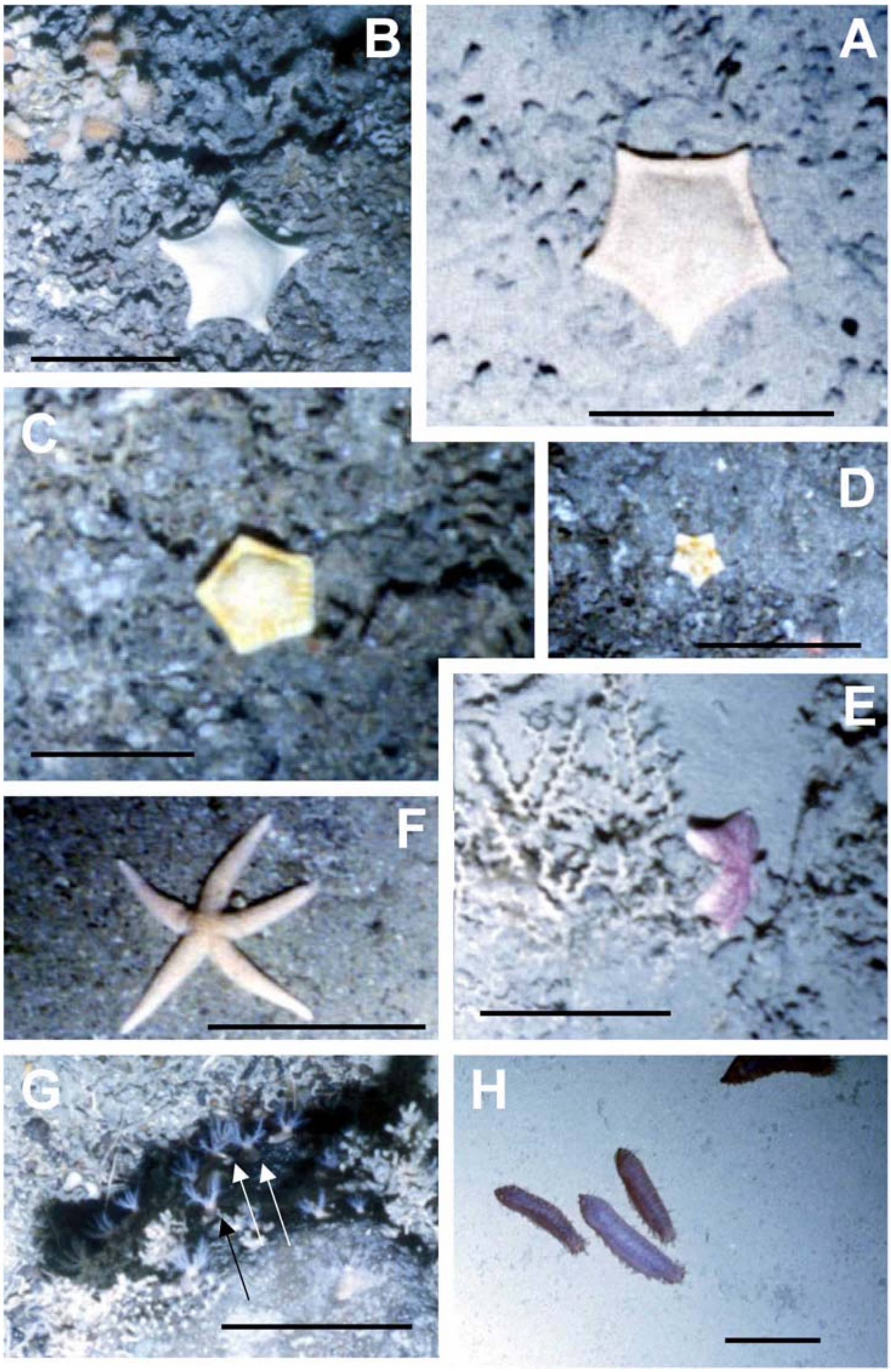



**Fig. 1.47:** Megafauna Echinodermata I: a) *Ceramaster* sp. (Kiel Mount), b) *Porania* (?) sp. (Castor Mound), c) Coloured *Ceramaster* (?) sp. (Joe's Nose), d) unidentified asteroid (Joe's Nose), e) *Poraniomorpha* sp. (Franken Mound), f) unidentified asteroid (Franken Mound), g) *Psolus* sp. (Kiel Mount), h) *Benthogyne* sp. (Kiel Mount). All scale bars refer to 10 cm length.

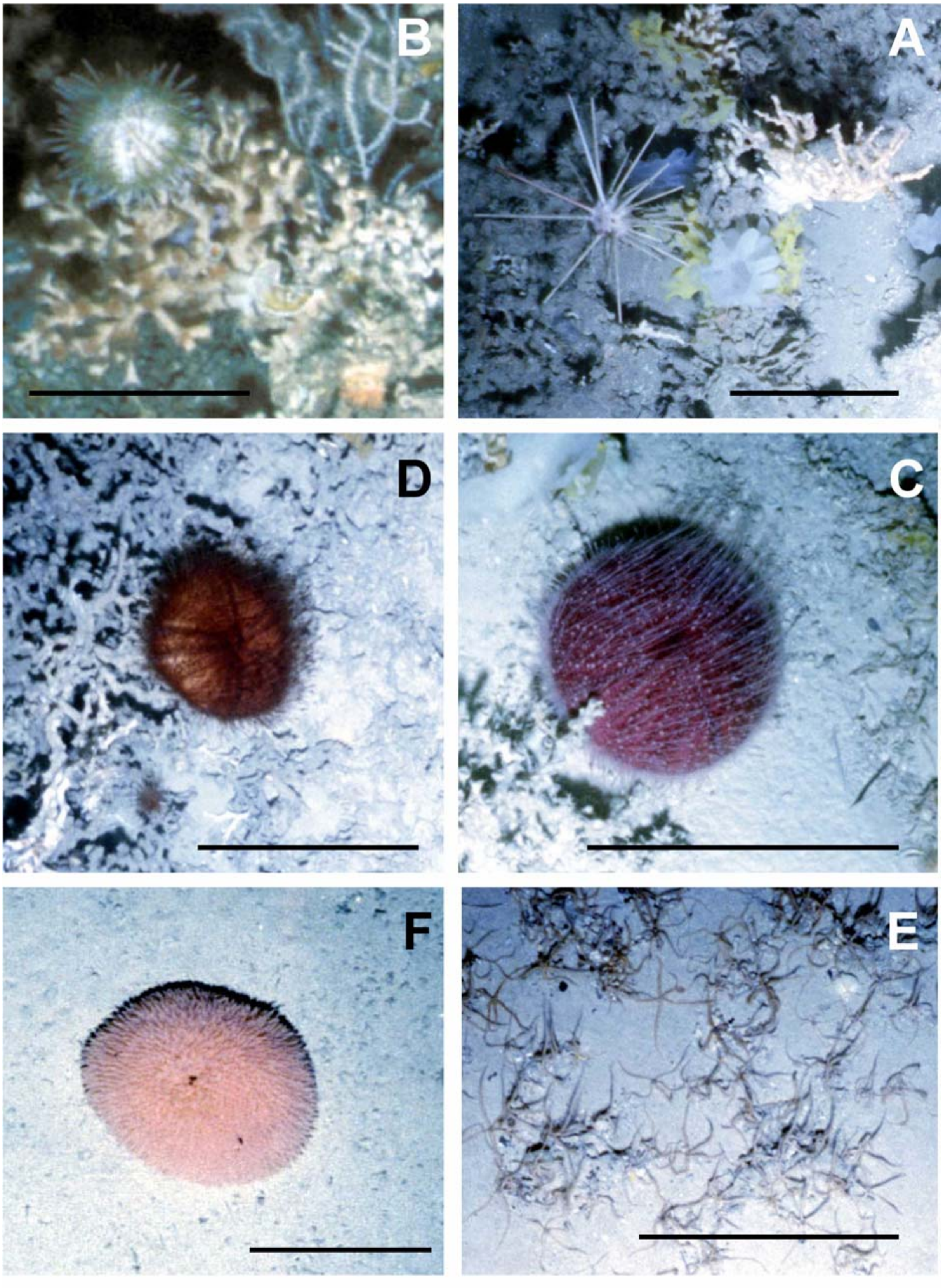



**Fig. 1.48:** Megafauna Echinodermata II: a) *Cidaris* cf. *cidaris* (Castor Mound), b) *Echinus* cf. *acutus* (Castor Mound), c) Echinothurid, probably *Hygrosoma* sp. or *Sperosoma* sp. (Kiel Mount), d) Echinothurid, probably *Araeosoma* sp. (Franken Mound), e) Aggregation of ophiuroids (Kiel Mount), f) Conundrum, probably not an echinoid but what (Kiel Mount)? All scale bars refer to 10 cm length.

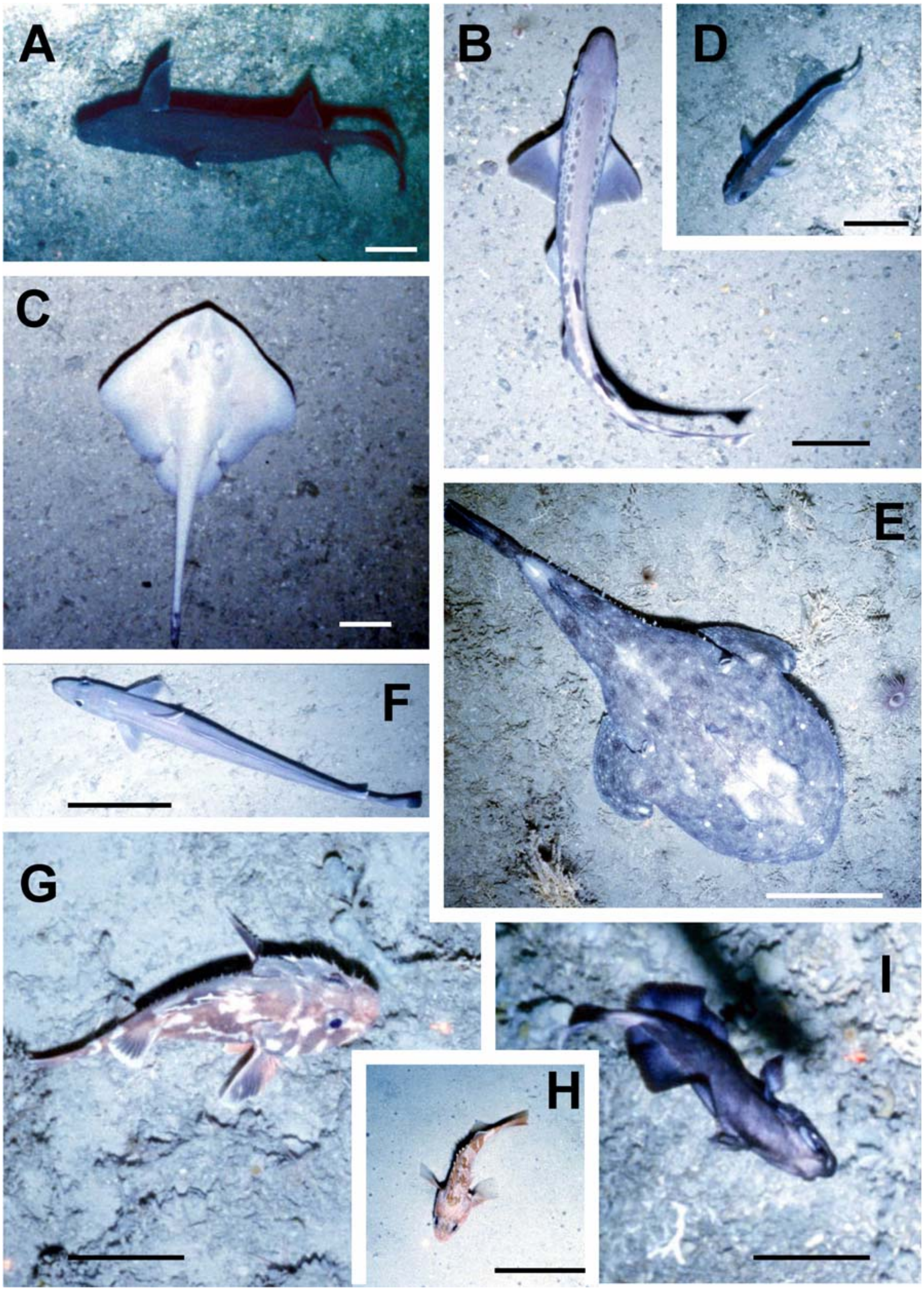



**Fig. 1.49:** Megafauna fishes: a) Sailfin-roughshark *Oxynotus paradoxus* (Kiel Mount), b) Blackmouth catshark *Galeus melastomus* (Joe's Nose), c) *Bathyraja* sp. (Kiel Mount), d) Atlantic codling *Lepidion eques* (Kiel Mount), e) Monkfish *Lophius piscatorius* (Erik Mound), f) Blue ling *Molva dypterygia* (Kiel Mount), g) Spiny scorpionfish *Trachyscorpia cristulata* (Kiel Mount), h) Blackbelly rosefish *Helicolenus dactylopterus* (Franken Mound), i) False boarsfish *Neocyttus helgae* (Kiel Mount). All scale bars refer to 10 cm length.

## 1.5 The Weather during R/V METEOR Voyage M61-1

When R/V METEOR left Lisbon on April 19th, 2004, a gale center 970 hPa over the Hebrides and a secondary low southwest of Ireland governed the Northeastern Atlantic. So the ship met with southwesterly winds 5 Bft when she put out to sea.

However there was another gale center 983 at 53 North 38 West. It intensified to 975 hPa by the next day, moving east quickly. On April 21st, the gale center of 972 hPa was in the vicinity of the Irish west coast before it turned north and began filling. Heading north to the Porcupine Sea Bight R/V METEOR experienced southwesterly gales of 7 to 8 Bft when the cold front extending from the gale center was near, abating to 5 Bft when it had passed.

The next gale center had already deepened to 980 hPa east of Newfoundland, but when nature repeats itself it does not do so exactly. Hence, this gale center turned north at longitude 30 West, reaching the southern rim of the Irminger Sea by April 23rd. R/V METEOR reached her first working area reporting southwesterly winds of 5 Bft sometimes up to 6 Bft.

The Atlantic Subtropical High, by the way, had been centered southwest of the Acores when the ship left port but had retreated to its winterly position near Bermuda and so had not been a prominent feature of the synoptic chart as yet. However, a wedge of 1026 hPa had hovered south of the Acores, and now that the gale centers were roaming waters more westerly than the days before this wedge had migrated northeast, being a high of 1028 over England on April 24th. The high then moved on to Scandinavia.

As the gale center moved further north slowly, moderate southwesterly winds were felt while coral samples were taken from the carbonate mounds.

The next gale center to pass the vicinity of Cape Race, Newfoundland, did so on April 25th when already at the peak of its development, 975 hPa. The strong advection of warm air to the east of it reintroduced the Acores High of 1030 hPa on April 26th at 50 North 20 West. At R/V METEOR´s position winds veered north 6 Bft.

Though sea level pressure in the gale center rose warm air advection continued so that the high was strengthened further. Meanwhile, lows began forming over northern France and the Bay of Biscay. On April 28th, the high was situated at 55 North 25 West, sea level pressure having risen to 1035 hPa. On the other hand, the lows had deepened to 1003 hPa. In consequence, strong north-easterly winds of 7 Bft inhibited the ship when she was heading for her second area of investigation, the Rockall Bank. Once having arrived there the winds abated to 5 Bft, and there were even light westerlies on April 30th. These were due to the fact that the lows moving north from Newfoundland had reached south-western Greenland, thereby inducing lows on the southeast coast of that island. Conditions for the development of gale centers being favourable there, the first one moved through Denmark Strait, its fronts reaching south from the center and thus weakening the northern rim of the dominant high.

That high moved west slowly, its strength being 1032 hPa.

The Rockall Bank was influenced little, and so the ship enjoyed moderate north-westerly winds on May 1st. However, the high strengthened again to 1035 hPa, and on the other hand, winds in the upper air changed towards the end of the voyage. These resulted in secondary lows forming on the Southeast Greenland coast moving in a more southerly direction, thereby shifting the main gale center south to Scotland when the ship called at Cork on May 5th. Strong north-westerly winds to gales had accompanied her there from the Rockall Bank on.

## 1.6 Station List M61-1

| Stat. No. | Gear | No. | Area | Date | Start | Coordinates | | | at depth | Coordinates | | | off bottom | Coordinates | | end stat. | Coordinates | | Observations and subsam-ples |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Time (UTC) | Lat. °N | Long. °W | depth (m) | Time (UTC) | Lat. °N | Long. °W | sampling depth (m) | Time (UTC) | Lat. °N | Long. °W | Time (UTC) | Lat. °N | Long. °W | |
| 202 | ROBIO | 1 | | 22.04.04 | 12:42 | | | 919 | | | | **919** | | 51°09,90 | 11°39,73 | 13:00 | | | flag down |
| 203 | OFOS | 1 | BMP: Castor | 22.04.04 | 17:25 | 51°26,56 | 11°47,07 | 1067 | 17:59 | 51°26,50 | 11°47,22 | **1063** | 19:05 | 51°25,83 | 11°47,25 | 19:31 | 51°25,65 | 11°47,20 | |
| 204 | OFOS | 2 | BMP: Pollux | 22.04.04 | 19.52 | 51°25,44 | 11°45,34 | 989-999 | 20:18 | 51°25,34 | 11°45,45 | **984** | 21:32 | 51°24,64 | 11°45,86 | 21:57 | 51°24,36 | 11°45,74 | |
| 205 | CTD/Ro | 1 | BMP: Galway | 22.04.04 | 22:46 | 51°27,87 | 11°45,05 | 923-925 | 23:10 | 51°27,85 | 11°45,07 | **924** | 23:11 | 51°27,85 | 11°45,07 | 23:29 | 51°27,86 | 11°45,08 | BWS 1;2 |
| 206 | CTD/Ro | 2 | BMP: Galway | 22.04.04 | 23:45 | 51°27,63 | 11°45,27 | 916-920 | 00:07 | 51°27,64 | 11°45,25 | **907** | 00:09 | 51°27,64 | 11°45,25 | 00:28 | 51°27,64 | 11°45,26 | BWS 3;4 |
| 207 | CTD/Ro | 3 | BMP: Galway | 23.04.04 | 00:41 | 51°27,45 | 11°45,28 | 864-871 | 01:02 | 51°27,44 | 11°45,30 | **859** | 01:03 | 51°27,44 | 11°45,30 | 01:20 | 51°27,43 | 11°45,31 | BWS 5;6. no bottom contact |
| 208 | CTD/Ro | 4 | BMP: Galway | 23.04.04 | 01:36 | 51°27,28 | 11°45,17 | 800-808 | 01:57 | 51°27,26 | 11°45,19 | **807** | 01:57 | 51°27,26 | 11°45,20 | 02:14 | 51°27,26 | 11°45,17 | BWS 7;8 |
| 209 | CTD/Ro | 5 | BMP: Galway | 23.04.04 | 02:29 | 51°27,10 | 11°45,14 | 797-813 | 02:48 | 51°27,09 | 11°45,12 | **786** | 02:49 | 51°27,09 | 11°45,13 | 03:05 | 51°27,09 | 11°45,14 | BWS 9;10 |
| 210 | CTD/Ro | 6 | BMP: Galway | 23.04.04 | 03:20 | 51°26,92 | 11°45,14 | 865-870 | 03:41 | 51°26,92 | 11°45,13 | **834** | 03:42 | 51°26,92 | 11°45,13 | 03:59 | 51°26,92 | 11°45,16 | BWS 11;12 |
| 211 | CTD/Ro | 7 | BMP: Galway | 23.04.04 | 04:11 | 51°26,79 | 11°45,19 | 886-890 | 04:31 | 51°26,80 | 11°45,19 | **865** | 04:32 | 51°26,80 | 11°45,19 | 04:49 | 51°29,79 | 11°45,21 | BWS 13;14 |
| 212 | CTD/Ro | 8 | BMP: Galway | 23.04.04 | 05.00 | 51°26,67 | 11°45,15 | 893-895 | 05:22 | 51°26,69 | 11°45,18 | **886** | 05:23 | 51°26,69 | 11°45,19 | 05:41 | 51°26,68 | 11°45,18 | BWS 15;16 |
| 213 | CTD/Ro | 9 | BMP: Little Galway | 23.04.04 | 05:54 | 51°26,52 | 11°45,43 | 873-884 | 06:13 | 51°26,53 | 11°45,42 | **880** | 06:14 | 51^26,53 | 11°45,42 | 06:30 | 51°26,52 | 11°45,43 | BWS 19;20 |
| 214 | CTD/Ro | 10 | BMP: Little Galway | 23.04.04 | 06:45 | 51°26,39 | 11°45,51 | 917-927 | 07:05 | 51°26,38 | 11°45,48 | **880** | 07:06 | 51°26,38 | 11°45,49 | 07:23 | 51°26,38 | 11°45,51 | BWS 17;18 |
| 215 | BG | 1 | BMP: Castor | 23.04.04 | 07:55 | 51°26,26 | 11°47,28 | 986-1003 | 08:27 | 51°26,25 | 11°47,20 | **994** | 08:29 | 51°26,25 | 11°47,20 | 08:48 | 51°26,25 | 11°47,20 | |
| 216 | BG | 2 | BMP: Therese | 23.04.04 | 09:18 | 51°25,72 | 11°46,26 | 892-904 | 09:47 | 51°25,72 | 11°46,26 | **898** | 09:48 | 51°25,72 | 11°46,26 | 10:06 | 51°25,72 | 11°46,26 | |
| 217 | BG | 3 | BMP: Little Therese | 23.04.04 | 10:34 | 51°26,03 | 11°45,88 | 886-902 | 10:54 | 51°26,03 | 11°45,88 | **888** | 10:55 | 51°26,03 | 11°45,88 | 11:14 | 51°26,03 | 11°45,88 | *Acanthogorgia* |
| 218 | BG | 4 | BMP: Little Galway | 23.04.04 | 11:38 | 51°26,51 | 11°45,43 | 871-881 | 12:03 | 51°26,51 | 11°45,43 | **871** | 12:04 | 51°26,51 | 11°45,43 | 12:22 | 51°26,51 | 11°45,43 | |
| 219 | ROBIO | 1 | Belgica | 23.04.04 | 16:17 | 51°09,90 | 11°39,73 | 919-918 | 16:25 | 51°09,90 | 11°39,73 | **919** | 16:26 | 51°09,90 | 11°37,73 | 17:10 | 51°09,90 | 11°37,73 | release lander |
| 220 | BCL | 1 | Belgica | 23.04.04 | 12:50 | 51°27,37 | 11°45,13 | 860 | 13:29 | 51°27,37 | 11°45,13 | | 13:30 | 51°27,37 | 11°45,13 | 13:50 | 51°27,37 | 11°45,13 | |
| 221 | GKG | 1 | BMP: Castor (N) | 23:04:04 | 19:26 | 51°26,47 | 11°47,22 | 1058 | 19:55 | 51°26,47 | 11°47,22 | **1059** | 19:56 | 51°26,47 | 11°47,22 | 20:21 | 51°26,47 | 11°47,22 | dropstone;dead coral fragments |
| 222 | GKG | 2 | BMP: Castor (Top) | 23:04:04 | 20:52 | 51°26,16 | 11°47,29 | 958-975 | 21:17 | 51°26,16 | 11°47,29 | **975** | 21:18 | 51°26,16 | 11°47,29 | 21:39 | 51°26,16 | 11°47,29 | |
| 223 | GKG | 3 | BMP: Castor (SW) | 23:04:04 | 22:05 | 51°25,87 | 11°47,39 | 1029 | 22.55 | 51°25,87 | 11°47,39 | **1029** | 22:56 | 51°25,87 | 11°47,39 | 23:20 | 51°25,87 | 11°47,39 | 12cm recovery |
| 224 | GKG | 4 | BMP: Pollux | 23:04:04 | 23:56 | 51°25,26 | 11°45,60 | 981 | 00.28 | 51°25,26 | 11°45,60 | **981** | 00:29 | 51°25,26 | 11°45,60 | 00:50 | 51°25,26 | 11°45,60 | |
| 225 | GKG | 5 | BMP: Pollux(Top) | 24.04.04 | 01:17 | 51°24,99 | 11°45,71 | 912-914 | 01:40 | 51°24,99 | 11°45,71 | **912** | 01:41 | 51°24,99 | 11°45,71 | 02:00 | 51°24,99 | 11°45,71 | |
| 226 | GKG | 6 | BMP: Pollux | 24.04.04 | 02:23 | 51°24,82 | 11°45,61 | 949-950 | 02:45 | 51°24,82 | 11°45,61 | **950** | 02:46 | 51°24,82 | 11°45,61 | 03:05 | 51°24,82 | 11°45,61 | |
| 227 | CTD/Ro | 11 | BMP: Galway | 24.04.04 | 03:54 | 51°27,18 | 11°44,47 | 924 | 04:17 | 51°27,17 | 11°44,43 | **924** | 04:18 | 51°27,17 | 11°44,43 | 04:38 | 51°27,16 | 11°44,45 | 924m BWS 21 |
| 228 | CTD/Ro | 12 | BMP: Galway | 24.04.04 | 04:55 | 51°27,14 | 11°44,88 | 886-888 | 05:17 | 51°27,13 | 11°44,91 | **888** | 05:18 | 51°27,13 | 11°44,91 | 05:34 | 151°27,12 | 11°44,91 | 888m BWS 22 |

| Stat. No. | Gear | No. | Area | Date | Start | Coordinates | | | at depth | Coordinates | | | off bottom | Coordinates | | end stat. | Coordinates | | Observations and subsam-ples |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Time (UTC) | Lat. °N | Long. °W | depth (m) | Time (UTC) | Lat. °N | Long. °W | sampling depth (m) | Time (UTC) | Lat. °N | Long. °W | Time (UTC) | Lat. °N | Long. °W | |
| 229 | CTD/Ro | 13 | BMP: Galway | 24.04.04 | 05:45 | 51°27,09 | 11°45,13 | 804-817 | 06:05 | 51°27,08 | 11°45,14 | **804** | 06:06 | 51°27,08 | 11°45,14 | 06:22 | 51°27,09 | 11°45,14 | 804m BWS 23 |
| 230 | CTD/Ro | 14 | BMP: Galway | 24.04.04 | 06:32 | 51°27,07 | 11°45,32 | 839-900 | 06:57 | 51°27,10 | 11°45,29 | **839** | 06:58 | 51°27,10 | 11°45,29 | 07:15 | 51°27,07 | 11°45,31 | 839m BWS 24 |
| 231 | CTD/Ro | 15 | BMP: Galway | 24.04.04 | 07:41 | 51°27,07 | 11°45,61 | 956-960 | 08:05 | 51°27,08 | 11°45,63 | **946** | 08:06 | 51°27,09 | 11°45,63 | 08:25 | 51°27,06 | 11°45,61 | 946m BWS 25 |
| 232 | CTD/Ro | 16 | BMP: Galway | 24.04.04 | 08:54 | 51°27,10 | 11°45,36 | 984-985 | 09:16 | 51°27,11 | 11°45,37 | **973** | 09:17 | 51°27,17 | 11°45,37 | 09:37 | 51°27,10 | 11°45,39 | 973m BWS 26 |
| 233 | CTD/Ro | 17 | BMP: Galway | 24.04.04 | 11:21 | 51°26,72 | 11°48,54 | 1040-1070 | 11:49 | 51°27,02 | 11°48,95 | **1066** | 11:51 | 51°27,03 | 11°49,00 | 12:22 | 51°27,40 | 11°49,39 | 1066m BWS 27 |
| 234 | MOC | 1 | Belgica | 24.04.04 | 13:55 | 51°29,83 | 11°42,10 | 845-1016 | | | | **845** | | | | 17:32 | 51°22,75 | 11°48,94 | |
| 235 | BCL | 1 | Belgica | 24.04.04 | 18:10 | 51°27,78 | 11°44,81 | 926 | 18:10 | 51°27,78 | 11°44,81 | **926** | 18:10 | 51°27,78 | 11°44,81 | 18:19 | 51°27,78 | 11°44,81 | send signals: 18:10 ; relea-sing lander |
| 236 | MOC | 2 | Belgica | 24.04.04 | 19:35 | 51°29,67 | 11°45,08 | 935-1037 | | | | **935** | | | | 22:49 | 51°22,65 | 11°45,58 | |
| 237 | MOC | 3 | Belgica | 25.04.04 | 00:22 | 51°30,35 | 11°45,05 | 972 | | | | **890** | | | | 02:54 | 51°25,14 | 11°45,42 | |
| 238 | BG | 5 | Belgica | 25.04.04 | 03:40 | 51°29,47 | 11°43,21 | 912 | 04:05 | 51°29,47 | 11°43,21 | **912** | 04:06 | 51°29,47 | 11°43,21 | 04:25 | 51°29,47 | 11°43,21 | |
| 239 | BG | 6 | Belgica | 25.04.04 | 04:39 | 51°29,11 | 11°43,32 | 814-847 | 05:02 | 51°29,11 | 11°43,32 | **818** | 05:03 | 51°29,11 | 11°43,32 | 05:20 | 51°29,11 | 11°43,32 | |
| 240 | BG | 7 | Belgica | 25.04.04 | 05:40 | 51°28,27 | 11°44,94 | 898-901 | 06:05 | 51°28,27 | 11°44,94 | **900** | 06:06 | 51°28,27 | 11°44,94 | 06:24 | 51°28,27 | 11°44,94 | |
| 241 | BG | 8 | Belgica | 25.04.04 | 06:48 | 51°27,31 | 11°44,06 | 863-899 | 07:13 | 51°27,31 | 11°44,06 | **878** | 07:13 | 51°27,31 | 11°44,06 | 07:32 | 51°27,31 | 11°44,06 | |
| 242 | BG | 9 | Belgica | 25.04.04 | 07:56 | 51°26,93 | 11°42,99 | 881 | 08:20 | 51°26,93 | 11°42,99 | **881** | 08:21 | 51°26,93 | 11°42,99 | 08:38 | 51°26,93 | 11°42,99 | |
| 243 | BG | 10 | Belgica | 25.04.04 | 08:56 | 51°26,69 | 11°42,66 | 778 | 09:22 | 51°26,69 | 11°42,66 | **778** | 09:23 | 51°26,69 | 11°42,66 | 09:39 | 51°26,69 | 11°42,66 | |
| 244 | MOC | 4 | Belgica | 25.04.04 | 11:01 | 51°29,47 | 11°45,06 | 942-966 | | | | **942** | | | | 13:55 | 51°24,93 | 11°45,38 | |
| 245 | DOS | 1 | Belgica | 25.04.04 | 15:50 | 51°27,34 | 11°45,15 | 806-848 | 16:26 | 51°27,28 | 11°45,23 | **806** | | | | 17:05 | | | |
| 246 | ROBIO | 2 | Belgica | 25.04.04 | 17:30 | 51°25,07 | 11°45,52 | 963 | | 51°25,07 | 11°45,52 | **963** | | 51°25,07 | 11°45,52 | 17:44 | 51°25,07 | 11°45,52 | |
| 247 | OFOS | 3 | BMP: Erik | 25.04.04 | 18:24 | 51°29,39 | 11°42,97 | 845-904 | 18:47 | 51°29,41 | 11°42,97 | **904** | 20:15 | 51°28,85 | 11°43,43 | 20:34 | 51°28,81 | 11°43,57 | |
| 248 | OFOS | 4 | Belgica | 25.04.04 | 21:57 | 51°24,73 | 11°41,27 | 675-764 | 22:19 | 51°24,75 | 11°41,28 | **764** | 23:23 | 51°24,15 | 11°41,17 | 23:41 | 51°24,08 | 11°41,13 | |
| 249 | CTD/Ro | 18 | BMP: Thérèse | 26.04.04 | 00:18 | 51°25,14 | 11°46,32 | 10061009 | 00:42 | 51°25,15 | 11°46,32 | **995** | 00:44 | 51°25,15 | 11°46,32 | 01:05 | 51°25,14 | 11°46,32 | 995m BWS 40 |
| 250 | CTD/Ro | 19 | BMP: Thérèse | 26.04.04 | 01:20 | 51°25,37 | 11°46,35 | 978-979 | 01:45 | 51°25,37 | 11°46,34 | **960** | 01:46 | 51°25,36 | 11°46,34 | 02:04 | 51°25,36 | 11°46,35 | 960m BWS 41 |
| 251 | CTD/Ro | 20 | BMP: Thérèse | 26.04.04 | 02:23 | 51°25,53 | 11°46,38 | 943-947 | 02:46 | 51°25,52 | 11°46,34 | **919** | 02:47 | 51°25,52 | 11°46,34 | 03:05 | 51°25,52 | 11°46,33 | 919m BWS 42 |
| 252 | CTD/Ro | 21 | BMP: Thérèse | 26.04.04 | 03:21 | 51°25,70 | 11°46,27 | 878-930 | 03:44 | 51°25,70 | 11°46,29 | **850** | 03:45 | 51°25,70 | 11°46,29 | 04:02 | 51°25,71 | 11°46,28 | 850m BWS 43 |
| 253 | CTD/Ro | 22 | BMP: Thérèse | 26.04.04 | 04:18 | 51°25,82 | 11°46,24 | 891-906 | 04:44 | 51°25,82 | 11°46,31 | **910** | 04:45 | 51°25,82 | 11°46,31 | 05:04 | 51°25,82 | 11°46,31 | 910m BWS 44 |
| 254 | CTD/Ro | 23 | BMP: Thérèse | 26.04.04 | 05:14 | 51°25,94 | 11°46,25 | 914-916 | 05:37 | 51°25,94 | 11°46,23 | **907** | 05:38 | 51°25,94 | 11°46,23 | 05:55 | 51°25,94 | 11°46,25 | 907m BWS 45 |
| 255 | CTD/Ro | 24 | BMP: Thérèse | 26.04.04 | 06:12 | 51°26,14 | 11°46,20 | 990-997 | 06:36 | 51°26,15 | 11°46,27 | **989** | 06:36 | 51°26,14 | 11°46,26 | 06:55 | 51°26,15 | 11°46,21 | 989m BWS 46 |
| 256 | CTD/Ro | 25 | BMP: Thérèse | 26.04.04 | 07:12 | 51°26,46 | 11°46,16 | 992 | 07:35 | 51°26,45 | 11°46,16 | **992** | 07:36 | 51°26,46 | 11°46,17 | 07:55 | 51°26,47 | 11°46,14 | Not released |

| Stat. No. | Gear | No. | Area | Date | Start | Coordinates | | | at depth | Coordinates | | | off bottom | Coordinates | | end stat. | Coordinates | | Observations and subsam-ples |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Time (UTC) | Lat. °N | Long. °W | depth (m) | Time (UTC) | Lat. °N | Long. °W | sampling depth (m) | Time (UTC) | Lat. °N | Long. °W | Time (UTC) | Lat. °N | Long. °W | |
| 257 | BCL | 2 | Belgica | 26.04.04 | 09:55 | 51°27,07 | 11°46,36 | 986 | 10:40 | 51°27,07 | 11°46,36 | **986** | 10:43 | 51°27,07 | 11°46,36 | 11:11 | 51°27,06 | 11°46,38 | |
| 258 | ROBIO | 2 | Belgica | 26.04.04 | 12:40 | 51°24,60 | 11°45,29 | 948-977 | | | | **977** | 12:41 | 51°24,60 | 11°45,29 | 13:35 | 51°25,08 | 11°45,61 | |
| 259 | BG | 11 | BMP: Galway | 26.04.04 | 13:12 | 51°27,30 | 11°45,26 | 850-867 | 13:40 | 51°27,30 | 11°45,26 | **858** | 13:41 | 51°27,30 | 11°45,26 | 13:59 | 51°27,30 | 11°45,26 | |
| 260 | TVG | 1 | Belgica | 26.04.04 | 14:36 | 51°24,28 | 11°41,21 | 636-673 | 15:01 | 51°24,31 | 11°41,19 | **636** | 16:11 | 51°24,35 | 11°41,33 | 16:29 | 51°24,35 | 11°41,33 | |
| 261 | MOC | 5 | Belgica | 26.04.04 | 18:38 | 51°24,93 | 11°45,68 | 857-971 | | | | **971** | | | | 21:12 | 51°30,99 | 11°45,05 | |
| 262 | MOC | 6 | Belgica | 26.04.04 | 23:11 | 51°25,18 | 11°45,08 | 854-972 | | | | **972** | | | | 02:04 | 51°31,14 | 11°45,15 | |
| 263 | BG | 12 | Belgica | 27.04.04 | 02:56 | 51°26,48 | 11°42,67 | 777-808 | 03:15 | 51°26,48 | 11°42,67 | **789** | 03:16 | 51°26,48 | 11°42,67 | 03:38 | 51°26,48 | 11°42,67 | |
| 264 | BG | 13 | Belgica | 27.04.04 | 04:03 | 51°26,08 | 11°42,06 | 678-721 | 04:26 | 51°26,08 | 11°42,06 | **694** | 04:27 | 51°26,08 | 11°42,06 | 04:43 | 51°26,08 | 11°42,06 | |
| 265 | BG | 14 | Belgica | 27.04.04 | 05:03 | 51°25,85 | 11°41,86 | 705-733 | 05:24 | 51°25,85 | 11°41,86 | **733** | 05:25 | 51°25,85 | 11°41,86 | 05:40 | 51°25,85 | 11°41,86 | |
| 266 | BG | 15 | Belgica | 27.04.04 | 05:58 | 51°25,56 | 11°42,21 | 763-795 | 06:24 | 51°25,56 | 11°42,21 | **764** | 06:25 | 51°25,56 | 11°42,21 | 06:43 | 51°25,56 | 11°42,21 | |
| 267 | MOC | 7 | Belgica | 27.04.04 | 07:17 | 51°25,05 | 11°45,03 | 947-970 | | | | **970** | | | | 09:54 | 51°30,08 | 11°45,15 | |
| 268 | MOC | 8 | Belgica | 27.04.04 | 11:36 | 51°25,23 | 11°45,09 | 974-859 | | | | **974** | | | | 14:26 | 51°30,96 | 11°45,13 | |
| 269 | BCL | 3 | Belgica | 27.04.04 | 15:39 | 51°26,54 | 11°46,45 | 1012 | 15:20 | 51°26,54 | 11°46,45 | **1012** | 15:25 | 51°26,54 | 11°46,45 | 15:55 | 51°26,54 | 11°46,45 | |
| 270 | SL-3m | 1 | Belgica | 27.04.04 | 16:35 | 51°25,00 | 11°45,74 | 933-962 | 16:56 | 51°24,99 | 11°45,74 | **934** | 16:57 | 51°24,99 | 11°45,74 | 17:22 | 51°24,06 | 11°45,74 | Penetr.: 3,5m; Recov. 277cm |
| 271 | SL-6m | 2 | Belgica | 27.04.04 | 17:49 | 51°24,99 | 11°45,67 | 927-934 | 18:11 | 51°25,00 | 11°45,71 | **932** | 18:12 | 51°25,00 | 11°45,71 | 18:35 | 51°25,00 | 11°45,74 | Penetr.: 6m; Recov. 405cm |
| 272 | GKG | 7 | Belgica | 27.04.04 | 19:59 | 51°20,20 | 11°14,18 | 812-813 | 20:18 | 51°20,20 | 11°41,19 | **813** | 20:19 | 51°20,20 | 11°41,19 | 20.39 | 51°20,21 | 11°41,21 | |
| 273 | GKG | 8 | Belgica | 27.04.04 | 21:09 | 51°20,22 | 11°41,59 | 761-763 | 21:26 | 51°20,21 | 11°41,58 | **763** | 21:07 | 51°20,21 | 11°41,58 | 21:46 | 51°20,21 | 11°41,59 | |
| 274 | GKG | 9 | Belgica | 27.04.04 | 22:40 | 51°24,23 | 11°41,39 | 646-655 | 22:56 | 51°24,24 | 11°41,28 | **646** | 22:57 | 51°24,24 | 11°41,28 | 23:16 | 51°24,26 | 11°41,33 | |
| 275 | GKG | 10 | Belgica | 27.04.04 | 23:38 | 51°24,74 | 11°41,65 | 785 | 23:58 | 51°24,73 | 11°41,65 | **785** | 23:59 | 51°24,73 | 11°41,66 | 00:22 | 51°24,74 | 11°41,67 | |
| 276 | GKG | 11 | Belgica | 28.04.04 | 00:54 | 51°27,15 | 11°43,61 | 905 | 01:21 | 51°27,16 | 11°43,61 | **905** | 01:22 | 51°27,16 | 11°43,61 | 01:46 | 51°27,14 | 11°43,62 | |
| 277 | GKG | 12 | Belgica | 28.04.04 | 02:07 | 51°28,34 | 11°44,80 | 900-902 | 02:37 | 51°28,33 | 11°44,78 | **901** | 02:38 | 51°28,33 | 11°44,78 | 03:02 | 51°28,32 | 11°44,79 | |
| 278 | CTD/Ro | 26 | BMP: N' Castor | 28.04.04 | 03:44 | 51°26,46 | 11°47,24 | 1064 | 04:25 | 51°26,47 | 11°47,24 | **1058** | 04:26 | 51°26,47 | 11°47,24 | 04:47 | 51°26,47 | 11°47,25 | BWS 47 |
| 279 | CTD/Ro | 27 | BMP: Pollux | 28.04.04 | 05:22 | 51°24,97 | 11°45,70 | 924-932 | 05:42 | 51°24,97 | 11°45,97 | **905** | 05:43 | 51°24,71 | 11°45,71 | 06:01 | 51°24,99 | 44°45,72 | BWS 48 |
| 280/1 | CTD/Ro | 28 | BMP: Escarpment S' Poseidon | 28.04.04 | 06:37 | 51°24,93 | 11°41,33 | 681-710 | 06:53 | 51°24,33 | 11°41,40 | | 06:59 | 51°24,33 | 11°41,40 | 08:13 | 51°24,38 | 11°41,40 | Not released |
| 280/2 | CTD/Ro | 28-b | BMP: Escarpment S' Poseidon | 28.04.04 | 07:42 | 51°24,35 | 11°41,37 | 692-711 | 07:55 | 51°24,36 | 11°41,36 | **680** | 07:56 | 51°24,36 | 11°41,36 | 08:13 | 51°24,38 | 11°41,38 | BWS 49, 48, |
| 281 | SL-6m | 3 | Belgica | 28.04.04 | 08:39 | 51°24,18 | 11°41,21 | 658-662 | 08:57 | 51°24,20 | 11°41,19 | **658** | | 51°24,19 | 11°41,19 | 10:50 | 51°24,20 | 11°41,20 | Penetr. 6m; Recov. 512cm |
| 282 | SL-3m | 4 | Belgica | 28.04.04 | 11:08 | 51°28,26 | 11°45,03 | 906-908 | 11:27 | 51°28,27 | 11°45,04 | **907** | 11:28 | 51°28,27 | 11°45,04 | 11:47 | 51°28,27 | 11°45,01 | |
| 283 | MUC | 1 | Belgica | 28.04.04 | 13:08 | 51°23,87 | 11°48,59 | 1160 | 13,39 | 51°23,86 | 11°48,57 | **1160** | 13,41 | 51°23,86 | 11°48,58 | 14.20 | 51°23,88 | 11°48,61 | |

| Stat. No. | Gear | No. | Area | Date | Start | Coordinates | | | at depth | Coordinates | | | off bottom | Coordinates | | end stat. | Coordinates | | Observations and subsam-ples |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Time (UTC) | Lat. °N | Long. °W | depth (m) | Time (UTC) | Lat. °N | Long. °W | sampling depth (m) | Time (UTC) | Lat. °N | Long. °W | Time (UTC) | Lat. °N | Long. °W | |
| 283/1 | CTD/Ro | 29 | BMP: SW' Galway | 28.04.04 | 14:22 | 51°23,88 | 11°48,61 | 1160 | 14:50 | 51°23,89 | 11°48,61 | **1160** | 14:52 | 51°23,89 | 11°48,61 | 15:15 | 51°23,88 | 11°48,60 | Not released |
| 283/2 | CTD/Ro | 29b | BMP: SW' Galway | 28.04.04 | 15:29 | 51°23,86 | 11°48,56 | 1165 | 15:57 | 51°23,86 | 11°48,58 | **1155** | 15:58 | 51°23,86 | 11°48,57 | 16:26 | 51°23,87 | 11°48,60 | BWS 50 |
| 284 | MB/PS | 1 | Kiel Mount - WRP | 30.04.04 | 07:34 | 56°40,40 | 17°33,55 | 837-1102 | | | | **1102** | | | | 08:12 | 56°40,43 | 17°24,440 | |
| 284 | MB/PS | 2 | Kiel Mount - WRP | 30.04.04 | 08:21 | 51°41,090 | 17°24,520 | 843-1118 | | | | **843** | | | | 08:58 | 56°41,25 | 17°33,59 | |
| 284 | MB/PS | 3 | Kiel Mount - WRP | 30.04.04 | 09:15 | 56°41,91 | 17°33,55 | 855-1112 | | | | **1112** | | | | 09:53 | 56°42,01 | 17°24,430 | |
| 284 | MB/PS | 4 | Kiel Mount - WRP | 30.04.04 | 10:12 | 56°42,770 | 17°24,331 | 892-1140 | | | | **892** | | | | 10:48 | 56°42,83 | 17°33,55 | |
| 284 | MB/PS | 5 | Kiel Mount - WRP | 30.04.04 | 10:58 | 56°43,64 | 17°35,49 | 894-1177 | | | | **1177** | | | | 11:37 | 56°43,71 | 17°24,404 | |
| 285 | BCL | 3 | Kiel Mount - WRP | 30.04.04 | 12:12 | 56°39,82 | 17°29,86 | 975 | 12:55 | 56°39,82 | 17°29,86 | **975** | 12:56 | 56°39,82 | 17°29,86 | 13:25 | 56°39,82 | 17°29,86 | |
| 286 | ROBIO | 3 | Kiel Mount - WRP | 30.04.04 | 13:50 | 56°40,03 | 17°27,94 | 934 | | | | **934** | | | | 14:08 | 56°40,03 | 17°27,94 | |
| 287 | OFOS | 5 | Kiel Mount - WRP | 30.04.04 | 14:39 | 56°41,47 | 17°30,57 | 902-1067 | 15:01 | 56°41,46 | 17°30,55 | **904** | 16:58 | 56°42,87 | 17°29,83 | 17:21 | 56°43,25 | 17°29,78 | |
| 288 | OFOS | 6 | West. Rockall Bank | 30.04.04 | 17:58 | 56°40,38 | 17°32,36 | 927-1060 | 18:24 | 56°40,41 | 17°31,95 | **1049** | 21:03 | 56°41,86 | 17°31,75 | 21:25 | 56°41,90 | 17°32,01 | |
| 289/1 | CTD/Ro | 30 | Kiel Mount - WRP | 30.04.04 | 22:00 | 56°40,29 | 17°31,47 | 1023 | 22:54 | 56°40,29 | 17°31,43 | **1022** | 22:55 | 56°40,29 | 17°31,43 | 23:17 | 56°40,30 | 17°31,44 | abort at 300m |
| 289/2 | CTD/Ro | 31 | Kiel Mount - WRP | 30.04.04 | 22:30 | 56°40,29 | 17°31,43 | 1021 | 22:54 | 56°40,29 | 17°31,43 | **1005** | 22:55 | 56°40,29 | 17°31,43 | 23:17 | 56°40,30 | 17°31,44 | BWS 57 |
| 290 | CTD/Ro | 32 | Kiel Mount - WRP | 30.04.04 | 23:33 | 56°41,18 | 17°31,26 | 912-916 | 23:53 | 56°41,17 | 17°31,24 | **897** | 23:54 | 56°41,18 | 17°31,25 | 00:11 | 56°41,18 | 17°31,25 | 897m BWS 58 |
| 291 | CTD/Ro | 33 | Kiel Mount - WRP | 01.05.04 | 00:25 | 56°41,85 | 17°31,26 | 840-842 | 00:47 | 56°41,85 | 17°31,27 | **842** | 00:48 | 56°41,85 | 17°31,27 | 01:05 | 56°41,85 | 17°31,28 | BWS 59 |
| 292 | CTD/Ro | 34 | Kiel Mount - WRP | 01.05.04 | 01:20 | 56°42,66 | 17°31,06 | 954-956 | 01:41 | 56°42,63 | 17°31,05 | **942** | 01:42 | 56°42,63 | 17°31,05 | 02:02 | 56°42,63 | 17°31,06 | 942m BWS 60 |
| 293 | CTD/Ro | 35 | Kiel Mount - WRP | 01.05.04 | 02:16 | 56°43,41 | 17°30,95 | 1091 | 02:41 | 56°43,37 | 17°31,00 | **1076** | 02:42 | 56°43,37 | 17°31,00 | 03:03 | 56°43,39 | 17°31,00 | BWS 61 |
| 294/1 | CTD/Ro | 36 | Kiel Mount - WRP | 01.05.04 | 03:29 | 56°42,45 | 17°34,53 | 1160 | | | | | | | | 03:50 | 56°42,40 | 17°34,53 | abort at 300m |
| 294/2 | CTD/Ro | 36 | Kiel Mount - WRP | 01.05.04 | 04:03 | 56°42,40 | 17°34,53 | 1161 | 04:28 | 56°42,44 | 17°34,53 | **1145** | 04:29 | 56°42,44 | 17°34,53 | 04:56 | 56°42,42 | 17°34,52 | BWS 62 |
| 295 | CTD/Ro | 37 | Kiel Mount - WRP | 01.05.04 | 05:16 | 56°42,05 | 17°32,19 | 959-961 | 05:37 | 56°42,03 | 17°32,20 | **947** | 05:38 | 56°42,03 | 17°32,20 | 05:56 | 56°42,01 | 17°32,21 | 947m BWS 69 |
| 296 | CTD/Ro | 38 | Kiel Mount - WRP | 01.05.04 | 06:20 | 56°41,61 | 17°30,05 | 904-905 | 06:40 | 56°41,60 | 17°30,04 | **888** | 06:41 | 56°41,60 | 17°30,04 | 07.00 | 56°41,61 | 17°30,03 | 888m BWS 70 |
| 297 | CTD/Ro | 39 | Kiel Mount - WRP | 01.05.04 | 07:27 | 56°40,96 | 17°27,73 | 942 | 07:48 | 56°40,94 | 17°27,71 | **924** | 07:49 | 56°40,94 | 17°27,71 | 08:08 | 56°40,97 | 17°27,70 | 924m BWS 71 |
| 298 | BCL | 3 | West. Rockall Bank | 01.05.04 | 08:27 | 56°39,60 | 17°29,02 | 951 | | | | **951** | 08:31 | 56°39,60 | 17°29,02 | 08:58 | 56°39,60 | 17°29,02 | recovery |
| 299 | ROBIO | 3 | West. Rockall Bank | 01.05.04 | 09:16 | 56°39,71 | 17°27,35 | 909-917 | | | | **917** | 09:16 | 56°39,71 | 17°27,35 | 1020 | 56°41,23 | 17°29,77 | recovery |
| 300 | TVG | 2 | Kiel Mount - WRP | 01.05.04 | 10:45 | 56°41,74 | 17°30,77 | 847-864 | 11:11 | 56°41,76 | 17°30,97 | **863** | 11:41 | 56°41,78 | 17°31,27 | 12:03 | 56°41,79 | 17°31,37 | |
| 301 | TVG | 3 | Kiel Mount - WRP | 01.05.04 | 12:23 | 56°41,75 | 17°31,18 | 853-904 | 13:49 | 56°41,77 | 17°31,17 | **854** | 13:30 | 56°41,94 | 17°31,46 | 13:51 | 56°41,95 | 17°31,45 | |
| 302 | MB/PS | 6 | Kiel Mount - WRP | 01.05.04 | 15:04 | 56'30,57 | 17'28,52 | 968-608 | | | | **968** | | | | 16:26 | 56'30,57 | 17'28,52 | |
| 302 | MB/PS | 7 | Kiel Mount - WRP | 01.05.04 | 16:40 | 56'29,75 | 17'09,17 | 610-963 | | | | **610** | | | | 18:04 | 56'29,75 | 17'09,17 | |
| 302 | MB/PS | 8 | Kiel Mount - WRP | 01.05.04 | 18:28 | 56°28,96 | 17°28,70 | 607-979 | | | | **979** | | | | 19:57 | 56°29,02 | 17°08,66 | |
| 303 | OFOS | 5 | Franken Mound | 01.05.04 | 20:52 | 56°29,22 | 17°17,84 | 678-683 | 21:10 | 56°29,29 | 17°17,91 | **678** | 00:31 | 56°30,59 | 17°18,53 | 00:49 | 56°30,57 | 17°18,54 | |

| Stat. No. | Gear | No. | Area | Date | Start | Coordinates | | | at depth | Coordinates | | | off bottom | Coordinates | | end stat. | Coordinates | | Observations and subsam-ples |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Time (UTC) | Lat. °N | Long. °W | depth (m) | Time (UTC) | Lat. °N | Long. °W | sampling depth (m) | Time (UTC) | Lat. °N | Long. °W | Time (UTC) | Lat. °N | Long. °W | |
| 304 | BG | 16 | Kiel Mount - WRP | 02.05.04 | 02:15 | 56°41,22 | 17°31,32 | 912-917 | 02:43 | 56°41,23 | 17°31,39 | **913** | 02:44 | 56°41,23 | 17°31,39 | 03:05 | 56°41,27 | 17°31,36 | |
| 305 | BG | 17 | Kiel Mount - WRP | 02.05.04 | 03:19 | 56°41,85 | 17°31,38 | 837-854 | 03:44 | 56°41,82 | 17°31,38 | **854** | 03:45 | 56°41,82 | 17°31,38 | 04:05 | 56°41,85 | 17°31,29 | |
| 306 | BG | 18 | Kiel Mount - WRP | 02.05.04 | 04:08 | 56°41,83 | 17°31,27 | 834-838 | 04:29 | 56°41,85 | 17°31,30 | **837** | 04:30 | 56°41,85 | 17°31,30 | 04:48 | 56°41,81 | 17°31,30 | |
| 307 | BG | 19 | Kiel Mount - WRP | 02.05.04 | 05:03 | 56°42,07 | 17°30,69 | 833-839 | 05:33 | 56°42,08 | 17°30,69 | **839** | 05:34 | 56°42,08 | 17°30,69 | 05:51 | 56°42,11 | 17°30,48 | |
| 308 | BG | 20 | Kiel Mount - WRP | 02.05.04 | 05:52 | 56°42,11 | 17°30,48 | 829-840 | 06:15 | 56°42,11 | 17°30,50 | **831** | 06:16 | 56°42,11 | 17°30,50 | 06:33 | 56°42,15 | 17°30,56 | |
| 309 | BG | 21 | Kiel Mount - WRP | 02.05.04 | 06:34 | 56°42,15 | 17°30,57 | 838-842 | 06:56 | 56°42,15 | 17°30,58 | **840** | 06:57 | 56°42,15 | 17°30,58 | 07:15 | 56°42,14 | 17°30,59 | |
| 310 | GKG | 13 | Kiel Mount - WRP | 02.05.04 | 08:26 | 56°40,50 | 17°31,71 | 1026-1029 | 08:49 | 56°40,49 | 17°31,74 | **1029** | 08:50 | 56°40,49 | 17°31,74 | 09:34 | 56°40,48 | 17°31,74 | |
| 311 | GKG | 14 | Kiel Mount - WRP | 02.05.04 | 10:05 | 56°39,80 | 17°29,82 | 968-975 | 10:26 | 56°39,81 | 17°29,80 | **971** | 10:27 | 56°39,81 | 17°29,80 | 10:52 | 56°39,78 | 17°29,95 | |
| 312 | SL | 5 | Kiel Mount - WRP | 02.05.04 | 11:30 | 56°39,82 | 17°29,82 | 970-972 | 11:58 | 56°39,83 | 17°29,82 | **972** | 11:59 | 56°39,83 | 17°29,83 | 12:23 | 56°39,81 | 17°29,80 | no recovery (banana) |
| 313 | GKG | 15 | Kiel Mount - WRP | 02.05.04 | 13:15 | 56°42,36 | 17°29,99 | 883-904 | 13:46 | 56°42,44 | 17°30,01 | **902** | 13:47 | 56°42,44 | 17°30,01 | 14:12 | 56°42,46 | 17°30,09 | |
| 314 | CTD/Ro | 40 | Franken Mound | 02.05.04 | 16:01 | 56°29,86 | 17°18,25 | 670-683 | 16:22 | 56°29,90 | 17°18,43 | **682** | 16:23 | 56°29,91 | 17°18,43 | 16:38 | 56°29,91 | 17°18,52 | BWS |
| 315 | BG | 22 | Franken Mound | 02.05.04 | 17:00 | 56°29,64 | 17°18,00 | 663-669 | 17:21 | 56°29,64 | 17°18,05 | **665** | 17:22 | 56°29,64 | 17°18,06 | 17:38 | 56°29,69 | 17°17,97 | |
| 316 | BG | 23 | Franken Mound | 02.05.04 | 17:39 | 56°29,69 | 17°17,97 | 665-669 | 17°58 | 56°29,72 | 17°18,01 | **667** | 17:59 | 56°29,71 | 17°18,00 | 18:13 | 56°29,72 | 17°18,09 | |
| 317 | BG | 24 | Franken Mound | 02.05.04 | 18:19 | 56°29,80 | 659-665 | 659-665 | 18:39 | 56°29,82 | 17°18,29 | **665** | 18:40 | 56°29,82 | 17°18,27 | 18:54 | 56°29,85 | 17°18,16 | |
| 318 | BG | 25 | Franken Mound | 02.05.04 | 18:56 | 56°29,84 | 17°18,15 | 645-662 | 19:17 | 56°29,90 | 17°18,19 | **645** | 19:18 | 56°29,90 | 17°18,19 | 19:29 | 56°29,90 | 17°18,23 | |
| 319 | BG | 26 | Franken Mound | 02.05.04 | 19:32 | 56°29,90 | 17°18,24 | 652-686 | 19:55 | 56°29,83 | 17°18,36 | **676** | 19:56 | 56°29,83 | 17°18,36 | 20:11 | 56°29,86 | 17°18,45 | |
| 320 | BG | 27 | Franken Mound | 02.05.04 | 20:12 | 56°29,86 | 17°18,44 | 665-682 | 20:30 | 56°29,82 | 17°18,31 | **668** | 20:31 | 56°29,83 | 17°18,31 | 20:44 | 56°29,80 | 17°18,20 | |
| 321 | BG | 28 | Franken Mound | 02.05.04 | 20:45 | 56°29,79 | 17°18,30 | 655-667 | 21:02 | 56°29,79 | 17°18,35 | **667** | 21:03 | 56°29,79 | 17°18,35 | 21:18 | 56°29,75 | 17°18,33 | |
| 322 | BG | 29 | Franken Mound | 02.05.04 | 21:26 | 56°29,83 | 17°18,54 | 675-694 | 21:49 | 56°29,85 | 17°18,76 | **693** | 21:50 | 56°29,85 | 17°18,77 | 22:04 | 56°29,85 | 17°18,86 | |

**Abbrevations**

Gear:
Robio - RObust BIOdiversity lander
OFOS – Ocean Floor Observing System
CTD/RO – CTD and Rosette water sampler
BG – grab sampler
BCL – BC-Lander
GKG – Giant box corer
MOC – Mocness
DOS – Deep-Sea Observation System

Gear:
TVG – TV-grab
SL – gravity corer
MB/PS – Multibeam/

Area:
BMP – Belgica Mound Province
WRP – Western Rockall Plateau

Observations:
BWS – bottom water sample

## 1.7 References


Alexander, S. P., DeLaca, T. E., 1987. Feeding adaptations of the foraminiferan *Cibicides refulgens* living epizoically and parasitically on the Antarctic scallop *Adamussium colbecki.* Biological Bulletins, 173: 136-159.

Altenbach, A.V. and Sarnthein, M., 1989. Productivity record in benthic foraminifera. In: W.H. Berger, V.S. Smetacek and G. Wefer (Editors), Productivity of the Ocean: Present and Past. pp. 255-269; New York (Wiley).

Altenbach, A.V., Pflaumann, U., Schiebel, R., Thies, A., Timm, S. and Trauth, M., 1999. Scaling percentages and distributional patterns of benthic foraminifera with flux rates of organic carbon. Journal of Foraminiferal Research, 29: 173-185.

Baas, J. H., Schönfeld, J. and Zahn, R., 1998, Mid-depth oxygen drawdown during Heinrich Events: evidence from benthic foraminiferal community structure, trace fossil tiering, and benthic $\delta^{13}C$ at the Portuguese Margin. Marine Geology, 152: 25-55.

Beaulieu, S.E., 2001. Colonization of habitat islands in the deep sea: recruitment to glass sponge stalks. Deep Sea Research Part I, 48: 1121-1137.

Bernhard, J. M. and Sen Gupta, B. K., 1999. Foraminifera of oxygen-depleted environments. In B.K. Sen Gupta (Editor), Modern Foraminifera. pp. 201-216; Dordrecht (Kluwer).

Bertram, M.A., Cowen, J.P., 1999. Temporal variations in the deep-water colonization rates of small benthic foraminifera: the results of an experiment on Cross Seamount. Deep-Sea Research Part I, 46: 1021-1049.

Beyer, A., Schenke, H.W., Klenke, M. Niederjasper, F. (2003): High resolution bathymetry of the eastern slope of the Porcupine Seabight.- Marine Geology, 198: 27-54.

Bouchet P. & Warén A., 1986 : Revision of the Northeast Atlantic bathyal and abyssal Aclididae, Eulimidae, Epitonidae (Mollusca, Gastropoda)Bollettino Malacologico, Suppl. 2: 297-576

Cannariato, K. G. and Kennett, J. P., 1999, Climatically related milliennial-scale fluctuations in strength of California margin oxygen-minimum zone during the past 60 k.y.: Geology, 27: 975-978.

Caralp, M. H., 1989. Abundance of *Bulimina exilis* and *Melonis barleeanum*: relationship to the quality of marine organic matter. Geo-Marine Letters, 9: 37-43.

Coles, G.P., Ainsworth, N.R., Whatley, R.C., and Jones, R.W., 1996. Foraminifera and Ostracoda from Quaternary carbonate mounds associated with gas seepage in the Porcupine Basin, Offshore Western Ireland. Revista Española de Micropaleontología, 28: 113-152.

De Mol, B., Van Rensbergen, P., Pillen, S., Van Herreweghe, K., Van Rooij, D., McDonnell, A., Huvenne, V., Ivanov, M., Swennen, R., Henriet, J.P. (2002): Large deep-water coral banks in the Porcupine Basin, southwest of Ireland.- Marine Geology, 188: 193-231.

Dobson, M. and Haynes, J.R., 1973. Association of foraminifera with hydroids on the deep shelf. Micropaleontology, 19: 78-90.

Ernst, S., Duijnstee, I., and Van der Zwaan, B., 2002. The dynamics of the benthic foraminiferal microhabitat: recovery after experimental disturbance. Marine Micropaleontology, 46: 343-361.

Fariduddin, M., and Loubere, P., 1997. The surface ocean productivity response of deeper water benthic foraminifera in the Atlantic Ocean. Marine Micropaleontology, 32: 289-310.

Fontanier, C., Jorissen, F.J., Licari, L., Alexandre, A., Anschutz, P. and Carbonel, P., 2002. Live benthic foraminiferal faunas from the Bay of Biscay: faunal density, composition, and microhabitats. Deep-Sea Research, 49: 751-785.

Freiwald, A. and Schönfeld, J., 1996. Substrate pitting and boring pattern of *Hyrrokkin sarcophaga* Cedhagen 1994 (Foraminifera) in a modern deep-water coral reef mound. Marine Micropaleontology, 28: 199-207.

Freiwald, A., Fosså, J.H., Grehan, A., Koslow, T. Roberts, J.M. (2004): Cold-water coral reefs.- UNEP-WCMC, Biodiversity Series, 22: 1-84.

Gage, J.D. (1986): The benthic fauna of the Rockall Trough: regional distribution and bathymetric zonation.- Proceedings of the Royal Society of Edinburgh, 88B: 159-174.

Gooday, A.J. and Hughes, J.A., 2002. Foraminifera associated with phytodetritus deposits at a bathyal site in the northern Rockall Trough (NE Atlantic): seasonal contrasts and a comparison of stained and dead assemblages. Marine Micropaleontology, 46: 83-110.

Gooday, A.J. and Lambshead, P.J.D., 1989. Influence of seasonally deposited phytodetritus on the benthic foraminiferal population in the bathyal northeast Atlantic: a species response. Marine Ecology Progress Series 58, 53-67.

Gooday, A.J., 1988. A response by benthic foraminifera to phytodetritus deposition in the deep sea. Nature, 332: 70-73.

Gooday, A.J., 2003. Benthic foraminifera (Protista) as tools in deep-water palaeoceanography: environmental influences on faunal characteristics. Advances in Marine Biology, 46: 1-90.

Haward, N.J.B. and Haynes, J.R. 1967. *Clamys opercularis* (Linnaeus) as a mobile substrate for Foraminifera. Journal of Foraminiferal Research, 6: 30-38.

Heron-Allen, A., and Earland, A. 1913. Clare Island Survey; Part 64 - The foraminifera of the Clare Island District, Co.Mayo, Ireland. Proceedings of the Royal Irish Academy, 31 (pt. 3): 1-188.

Jeffreys, J. G. (1882). "On the Mollusca procured during the 'Lightning' and 'Porcupine' Expeditions, 1868-70. Part 5." Proceedings of the Zoological Society of London: 657-687.

Jorissen, F.J., de Stigter, H.C. and Widmark, J.G.V., 1995. A conceptual model explaining benthic foraminiferal microhabitats. Marine Micropaleontology, 26: 3-15.

Kaiho, K., 1994. Benthic foraminiferal dissolved-oxygen index and dissolved oxygen levels in the modern ocean. Geology, 22: 719-722.

Langezaal, S., 2003. The foraminiferal-bacterial connection: an interdisciplinary study of meiofaunal behaviour in the deeper marine redox zone. Geologica Ultraiectina, 229: 1-239.

Lees, A., Buller, A.T., and Scott, J., 1969. Marine carbonate sedimentation processes, Connemara, Ireland. Reading University Geological Reports, 2: 1-64.

Lutze, G.F. and Altenbach, A., 1991. Technik und Signifikanz der Lebendfärbung benthischer Foraminiferen in Bengalrot. Geologisches Jahrbuch, A128: 251-265.

Mullineaux, L.S. and Butman, C.A., 1990. Recruitment of encrusting benthic invertebrates in boundary-layer flows: a deep water experiment on Cross Seamount. Limnology and Oceanography, 35: 409-423.

Murray, J.W. and Bowser, S.E., 2000. Mortality, protoplasm decay rate, and reliability of staining techniques to recognize ‘living’ foraminifera: a review: Journal of Foraminiferal Research, 30: 66-70.

Murray, J.W., 1970. Foraminifers of the Western Approaches to the English Channel. Micropaleontology, 16: 471-485.

Murray, J.W., 2001. The niche of benthic foraminifera, critical thresholds and proxies. Marine Micropaleontology, 41: 1-7.

Oschmann, W., 1990. Dropstones - Rocky mini-islands in high-latitude pelagic soft substrate environments. Senckenbergiana Maritima, 21: 55-75.

Pfannkuche, O. and P. Linke (2003). "GEOMAR Landers as Long-Term Deep-Sea Observatories." Sea Technology 44(9): 50-55.

Roberts, JM, OC Peppe, LA Dodds, DJ Mercer, WT Thomson, JD Gage and DT Meldrum (in press) Monitoring environmental variability around cold-water coral reefs: the use of a benthic photolander and the potential of seafloor observatories. Deep-Water Corals & Ecosystems. Eds. Freiwald A & Roberts JM, Springer Special volume.

Schönfeld, J., 1997. The impact of the Mediterranean Outflow Water (MOW) on Benthic foraminiferal assemblages and surface sediments at the southern Portuguese continental margin. Marine Micropaleontology, 29: 211-236.

Schönfeld, J., 2001. Benthic foraminifera and pore-water oxygen profiles. A re-assessment of species boundary conditions at the western Iberian Margin. Journal of Foraminiferal Research, 31: 86-107.

Schönfeld, J., 2002. A new benthic foraminiferal proxy for near-bottom current velocities in the Gulf of Cadiz, northeastern Atlantic Ocean. Deep-Sea Research, 49: 1853-1875.

Seidov, D., and Haupt, B.J., 1997. Simulated ocean circulation and sediment transport in the North Atlantic during the last glacial maximum and today. Paleoceanography, 12: 281–305.

Taviani, M. and B. Sabelli (1982). "*Iphitus* (Mollusca, Gastropoda) a deep-water genus new to the Mediterranean Sea." Atti del V. Convegno della Società Malacologica Italiana: 129-131.

Van der Zwaan, G. J., Duijnstee, I. A. P., den Dulk, M., Ernst, S. R., Jannink, N. T. and Kouwenhoven, T. J., 1999. Benthic foraminifers: proxies or problems? A review of paleocological concepts. Earth-Science Reviews, 46: 213-236.

Van Rooij, D., De Mol, B., Huvenne, V., Ivanov, M., Henriet, J.P. (2003): Seismic evidence of current-controlled sedimentation in the Belgica mound province, upper Porcupine slope, southwest of Ireland.- Marine Geology, 195: 31-53.

Warén, A. (1991). "New and little known mollusca from Iceland and Scandinavia." Sarsia 76: 53-124.

Weston, J.F., 1982. Distribution and ecology of recent deep sea benthic foraminifera in the Northeast Atlantic Ocean. PhD Thesis University of Exeter, 442 pp. (unpubl.).

Weston, J.F., 1985. Comparison between recent benthic foraminiferal faunas of the Porcupine Seabight and western approaches continental slope. Journal of Micropalaeontology, 4: 165-183.